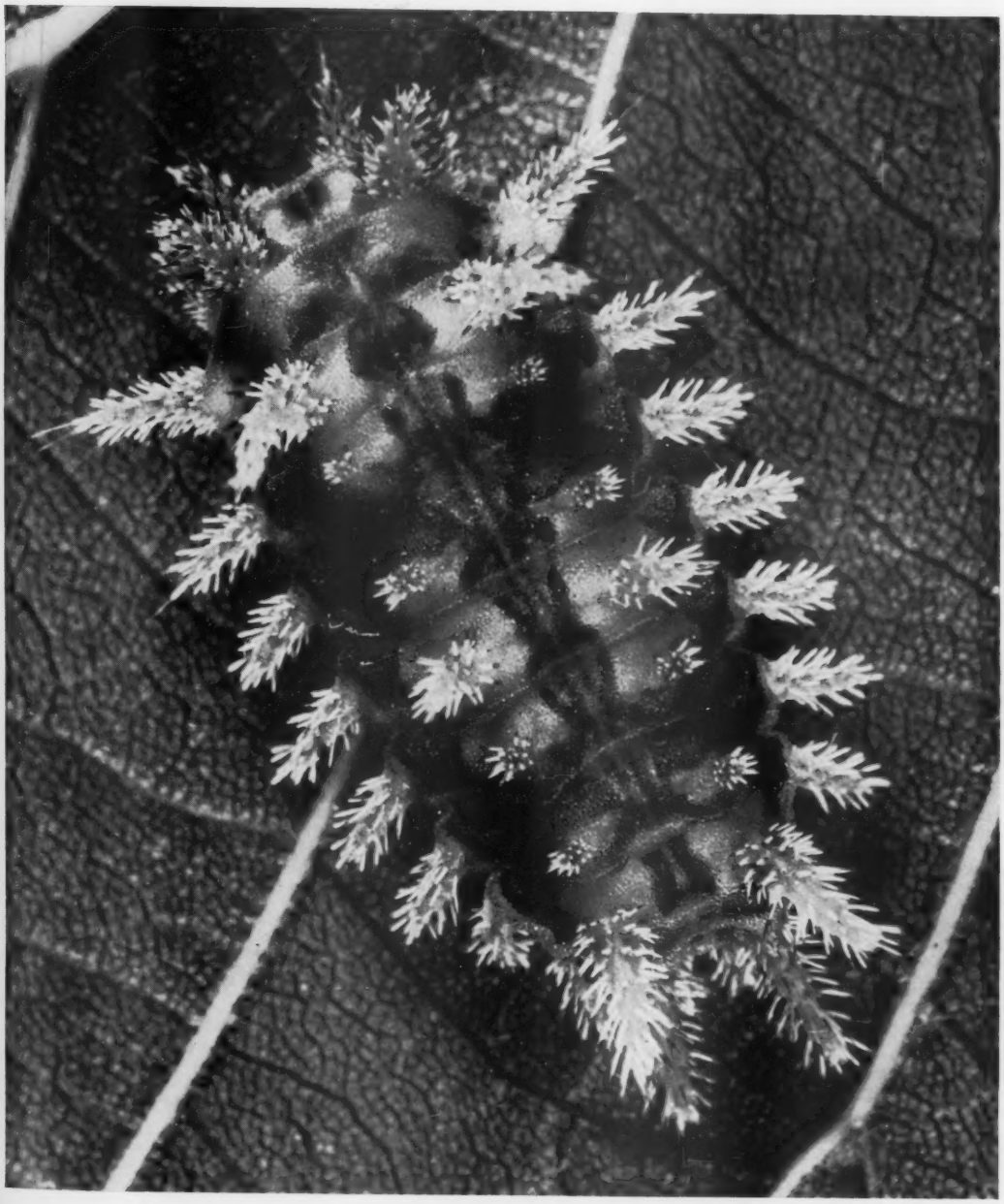
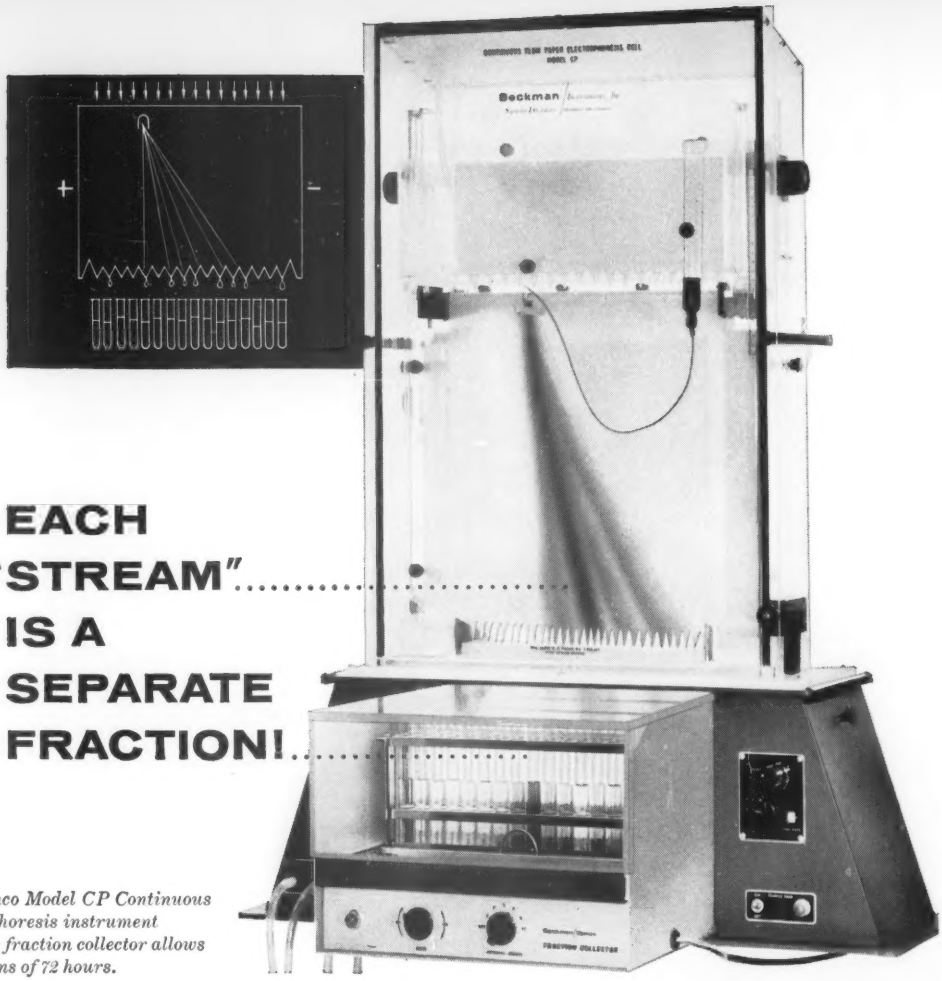
SCIENCE

13 November 1959

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE





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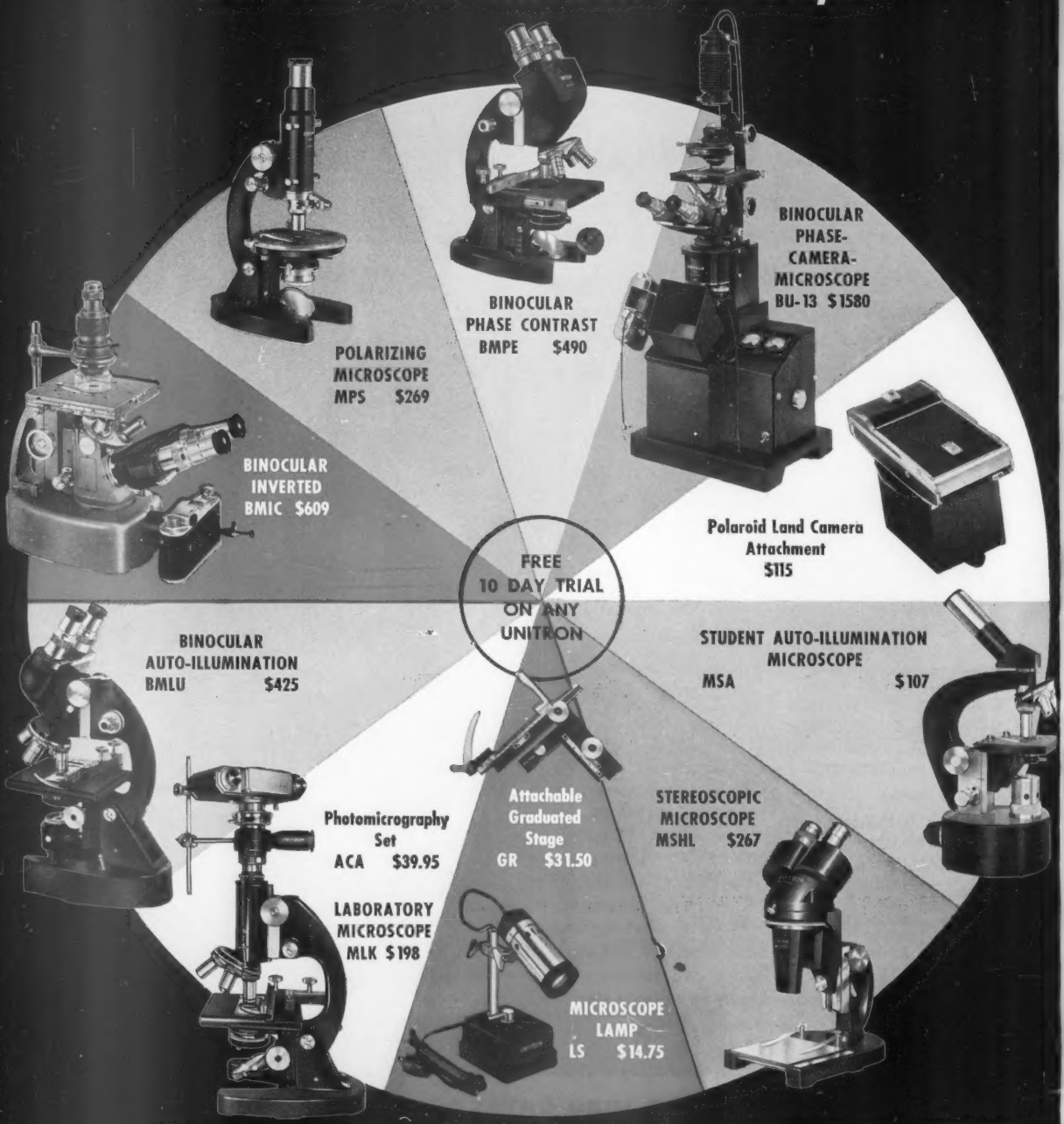

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13 November 1959, Volume 130, Number 3385

SCIENCE

Cover The spiny oak-slug caterpillar (*Euclea delphinii* Bdv) feeds on broad-leaf trees, such as basswood and apple. The adult moth emerges in June after a complete metamorphosis requiring one year. This insect does not cause any great degree of damage since it is not common. This is probably the result of high parasitism. Its only known parasite is *Zenillia blanda* (O.S.), a large gray fly (Tachinid). The maggot lives within the host caterpillar and eventually kills it, completing its development in the body wall and emerging as an adult fly. [Ross Jackson]

Robert Boyle...of the usefulness of mathematicks

"...I consider that without understanding as much of the abstruser part of geometry, as Archimedes or Apollonius, one may understand enough to be assisted by it in the contemplation of nature; and that one needs not know the profoundest mysteries of it to be able to discern its usefulness...I confess that after I began...to discern how useful mathematicks may be made to physicks, I have often wished that I had employed about the speculative part of geometry, and the cultivation of the specious Algebra I had been taught very young, a good part of that time and industry that I spent about surveying and fortification...and other practick parts of mathematicks."

—Of the Usefulness of Mathematicks... 1663

EXPERIMENT:

The analytical determination of proper balance between price and performance in lab glassware

Here's an experiment which you will be interested in trying. Though it pertains more to economy than to a physical state or condition, it does offer the sound analytical reasoning which you, as a scientist, must welcome.

The premise is this: laboratory glassware is an "expense" item in schools and colleges and by cutting this expense substantially every science instructor makes available to himself additional money with which to purchase other equipment for his laboratory.

This premise is based, first, on the fact that *quality* is maintained and, second, that the saving involved is substantial enough to warrant this time necessary to effect it.

Actually, this experiment demands little analytical determination to ascertain the possible savings involved. One glance at the comparative price chart listed below will show you the kind of savings to which we refer.

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COMPARATIVE LIST PRICE CHART

ITEM	BRAND A	BRAND B	DOERR
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PIPETTE (1 ml) (Ostwald)	1.14	1.28	0.81
CENTRIFUGE TUBE (15 ml)	1.28	1.28	0.69
FLASK (100 ml) (Glass Stoppered)	2.73	3.01	1.99
CYLINDER (100 ml)	2.71	2.94	1.48
SEPARATORY FUNNEL (250 ml) (Squibb)	6.22	6.56	5.21

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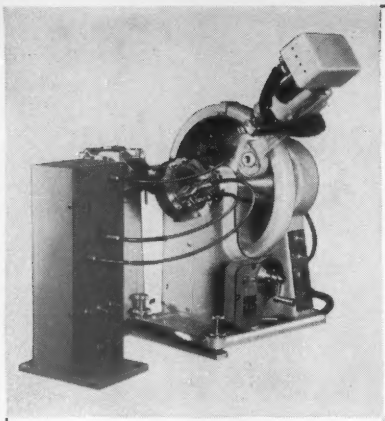
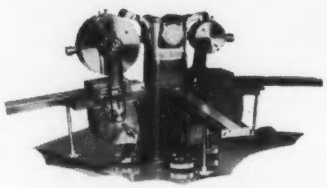
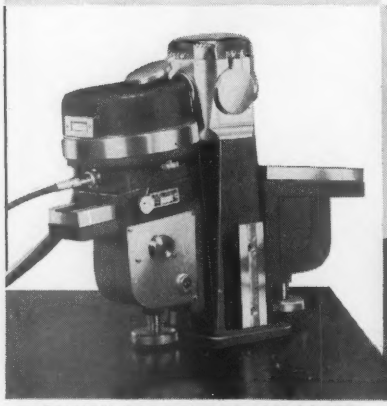


POLE FIGURE DEVICE

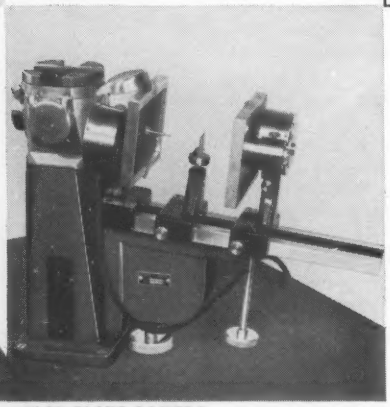
The Pole Figure Device permits quantitative preferred orientation studies by electronic means. It consists of a sample holder replacing the standard holder in the goniometer and a control unit which imparts the necessary angular rotations to the sample by flexible shafts. Four individual motor drives are provided. The specimen can be rotated selectively about two mutually perpendicular axes for measurement of reflection intensity at various points of the polar projection, and oscillated in its own plane to obtain an integrated reading. Intensities are recorded on the diffractometer chart and transferred to a polar net for plotting the pole figure.





PRECISION BACK-REFLECTION CAMERA

Accurately determines lattice parameters of powdered or ground solid specimens. This camera has a 60 mm. radius and provides optimum resolution at relatively short exposures. Camera body may be evacuated or filled with a light gas for higher recorded intensities. Specimen oscillation is provided by a built-in electric motor.

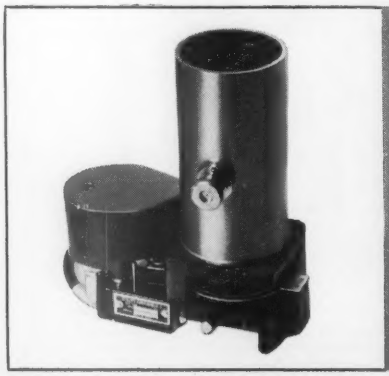


FLAT-PLATE CAMERA

This camera provides facilities for numerous forms of investigations which cannot be as effectively conducted with other cameras. It permits both forward and back reflection techniques, is applicable for Laue work, and may be used with monochromatic or filtered radiation. Applications include plastics, metals, powdered materials, fibers and in some cases semi-solids and liquids.

X-

The central

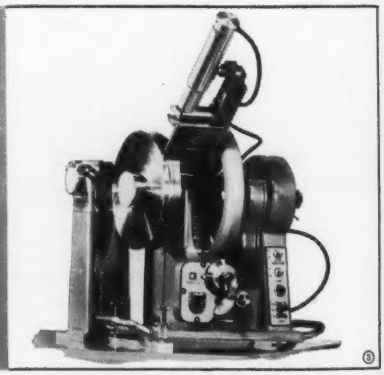


SINGLE CRYSTAL CYLINDRICAL CAMERA

Provides oscillatory or rotational movement of single crystal specimens recorded on a stationary, cylindrically bent 5 by 7 inch film. It records reflections for each of the major axes of a single crystal through ranges of values of the glancing angles, for cell constant determinations, identification of space groups and other data leading to the determination of the position of the atoms in the unit cell.

MICRO CAMERA

A specialized camera used for the investigation of minute sections. The precisely machined camera body is gas-tight and has a hose connection for pressure reduction or gas filling. Useful in determining the structures of natural and synthetic fibers, sheets, films and many physiological substances.



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Norelco Powder Cameras are available in either 114.59 mm. or 57.3 mm. diameter sizes. They are designed for recording diffraction patterns of powdered specimens, fibers or drawn wires. These cameras feature clean, brilliant patterns, short exposures, a unique centering device for specimen positioning and two interchangeable collimating systems.

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source of basic research data

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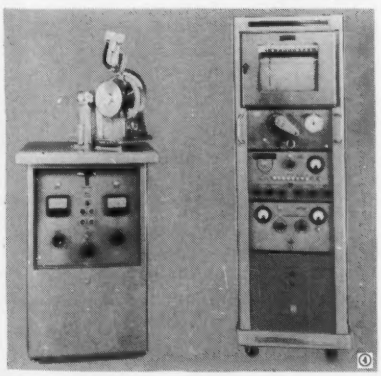

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Permits automatic recording of the diffraction spectrum by the addition of a wide range goniometer and electronic circuit panel to the basic diffraction unit. High speed detection counters and electronic circuitry used in place of, or as a supplement to, diffraction cameras provides rapid and more accurate interpretations through high quantum efficiency and excellent linearity of counting rates. The basic unit of the diffractometer is always available as a four-window radiation source for the simultaneous operation of both cameras and goniometers.

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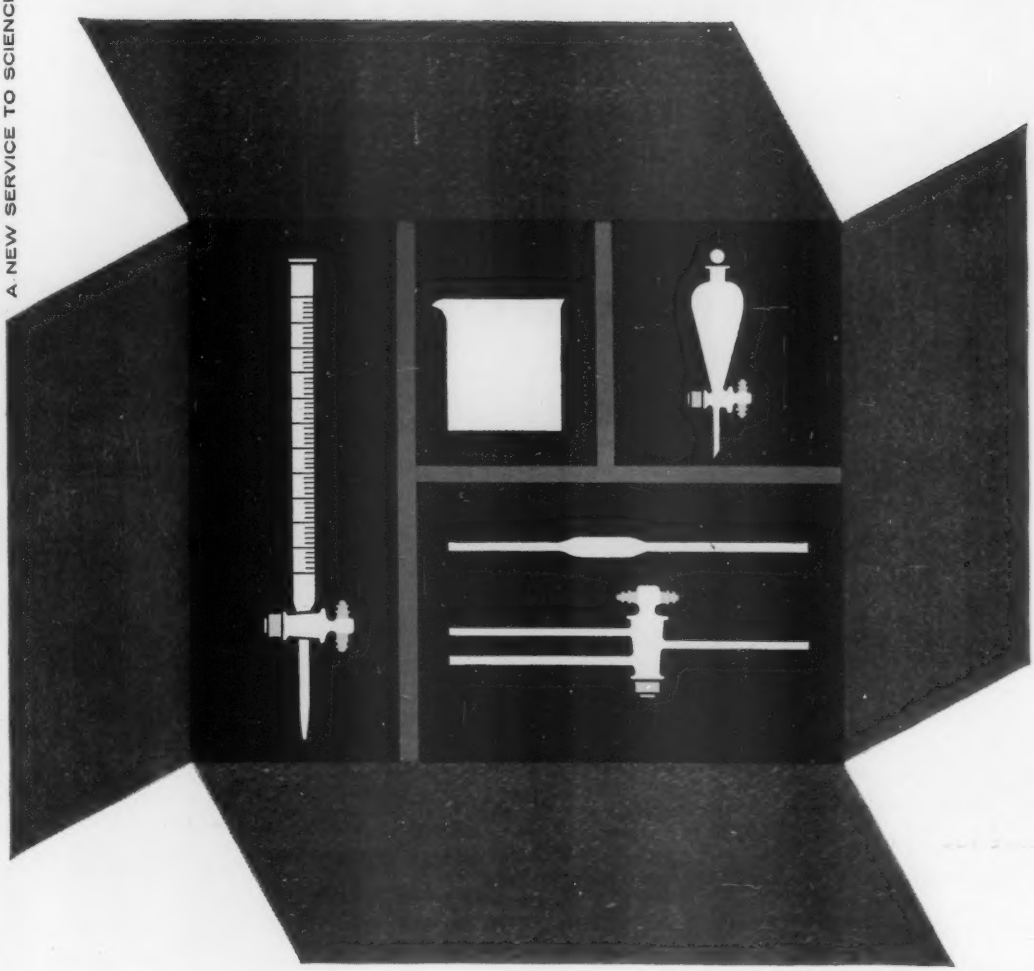

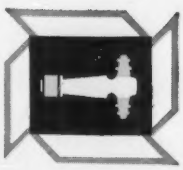

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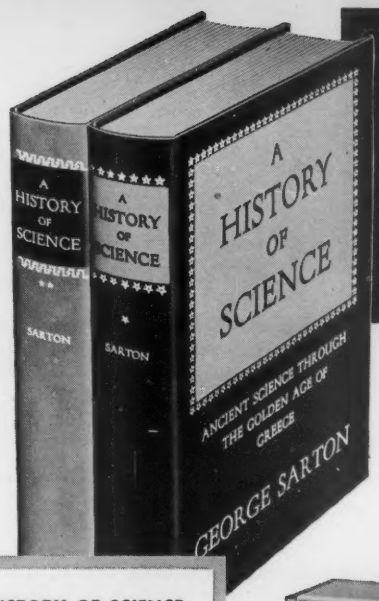

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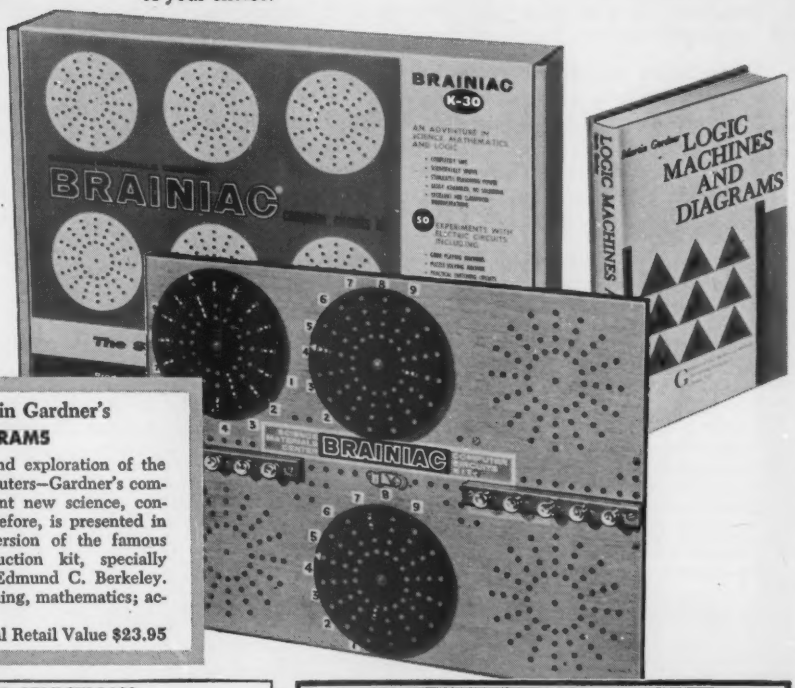

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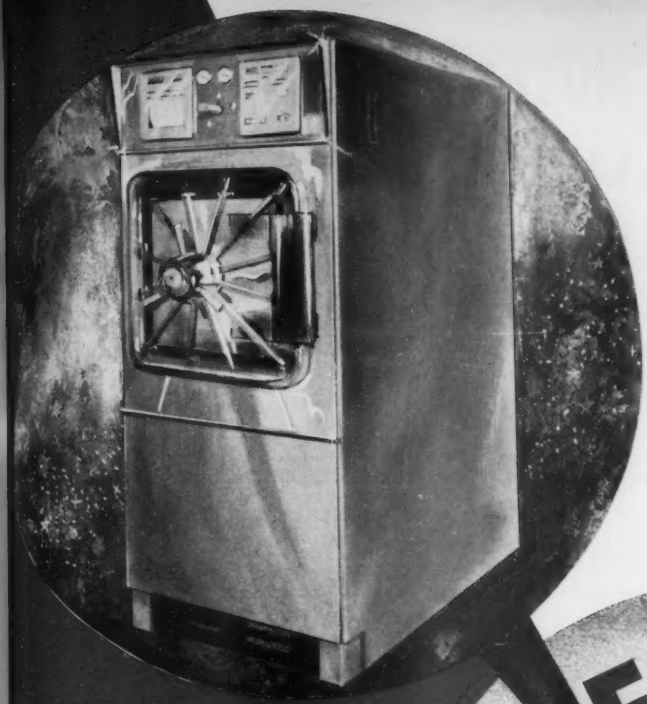

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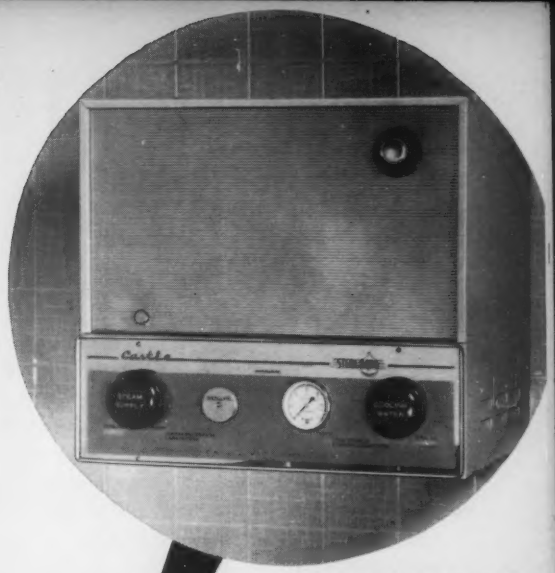

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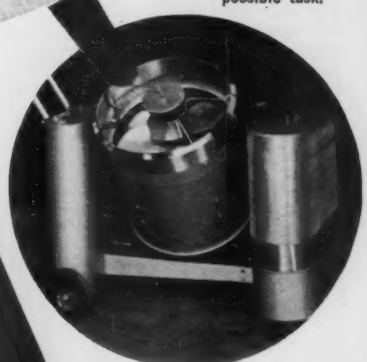

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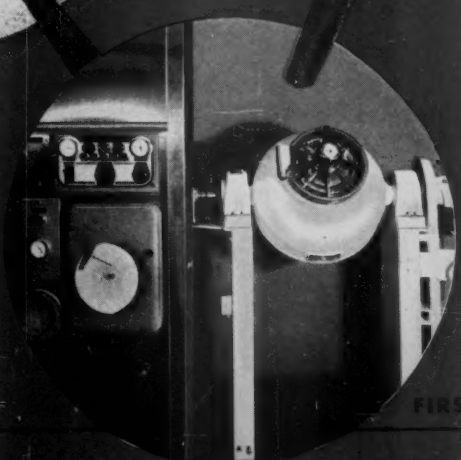

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Chicago, 26-31 December 1959

The four hotels for the AAAS Chicago meeting have established special low rates and have reserved large blocks of rooms at each level within the price ranges quoted. Thus everyone making room reservations for the AAAS meeting is assured substantial savings. Further, all confirmations will state the room rate assigned.

The list of hotels and their rates and the reservation coupon below are for your convenience in making your hotel reservation in Chicago. Please send your application, *not* to any hotel directly, but to the AAAS Housing Bureau in Chicago and thereby avoid delay and confusion. The experienced Housing Bureau will make assignments promptly; a confirmation will be sent you in two weeks or less.

If desired, the hotels will add a cot at $3.00 per night—except that all children under 12 are free. Mail your application *now* to secure your first choice of desired accommodations. All requests for reservations must give a definite date and estimated hour of arrival, and also probable date of departure.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

**No sessions in public rooms.* For a list of the headquarters of each participating society and section, see page 228, *Science*, 24 July.

Rates for Rooms with Bath

Hotel	Single	Double Bed	Twin Bed	Suite
Morrison	$6.50— 9.00	$9.00—13.00	$11.00—15.00	$30.00 and up
Hamilton	6.50— 9.50	9.00—13.00	11.00—15.00	25.00 and up
La Salle	7.50—10.00	10.50—13.00	12.50—15.50	35.50 and up
Sherman	7.45—12.45	11.45—16.45	14.45—19.50	28.50 and up
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First Choice Hotel ..... **Second Choice Hotel** ..... **Third Choice Hotel** .....

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(Individual requesting reservation) (Please print or type)

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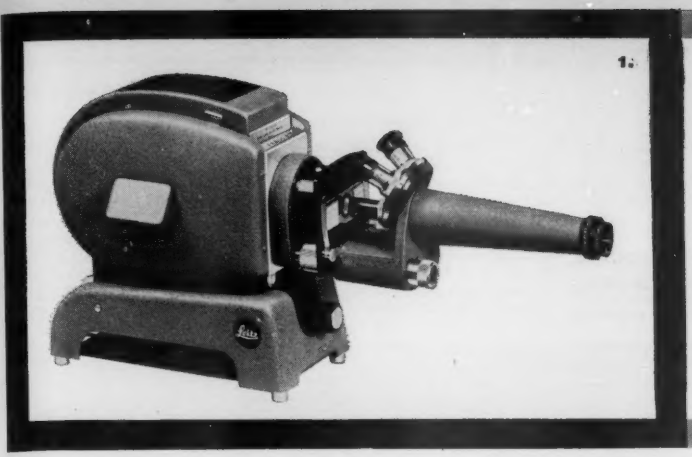
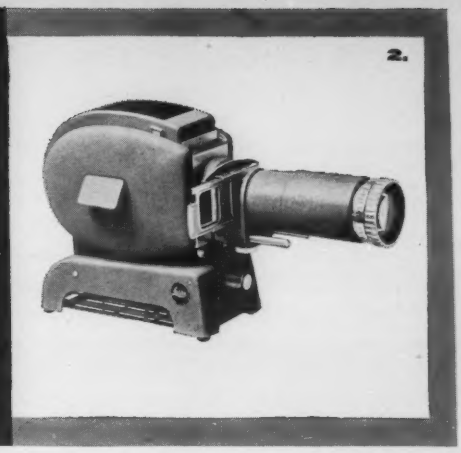
(Street) (City and Zone) (State)

Mail this now to the Housing Bureau. Rooms will be assigned and confirmed in order of receipt of reservation.





switch in seconds { *from projection of microscope slides to projection of transparencies with the*

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The ultimate in convenience for use in classroom, conference room or lecture hall, the PRADO Micro-Projector delivers screen images of unrivalled brilliance, clarity and definition. With Micro Attachment it produces magnifications up to 2400x on screens at a distance up to 40 feet; with a film slide carrier and lens inserted, the PRADO projects 2" x 2" or of 2¾" x 2¾" transparencies. And you can switch from micro to film slides in seconds –easily. The revolving nosepiece of the Micro Attachment holds three objectives: 3.5x, 10x and 25x. The high power objective is equipped with spring-loaded mount. Micro attachments are available which allow the stage to be placed in a horizontal position to accommodate wet mounts.

Light from the 500-watt lamp is projected through aspheric condensers in the PRADO, which is blower-cooled.

The PRADO Micro-Projector is portable, and may be carried easily from room to room and used wherever there is an electrical outlet.

For illustrated PRADO Micro-Projector Brochure, write to Dept. SC-11.

1. PRADO as Micro-Projector for microscopic slides **2.** PRADO as standard projector for film slides **3.** Attachable reflecting prism for tracings **4.** Polarizing Attachment for polarization demonstration **5.** Large Vertical Micro Attachment for wet mounts

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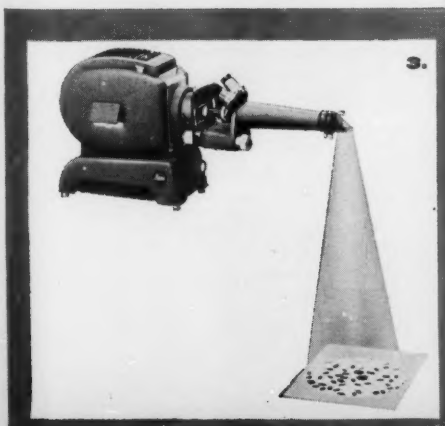

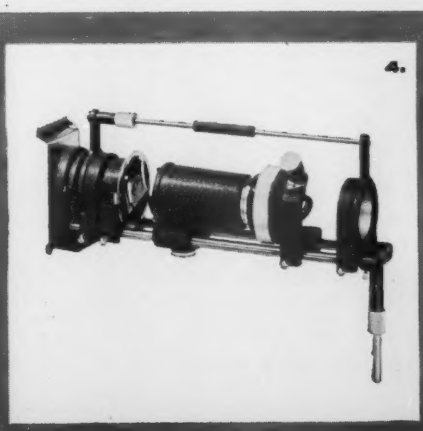

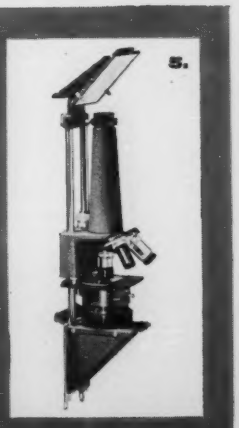

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Letters

Sex Chromatin

In a recent article (*1*), I favored the view that the sex chromatin represents heterochromatic regions of the two X chromosomes of female cells. The assumption of somatic pairing of the X chromosomes is an unsatisfactory aspect of this hypothesis. Somatic pairing of chromosomes is well known in many species of insects and has been described in the newt and frog (*2*). But evidence for such a relationship between the X chromosomes or other homologous chromosomes in somatic cells of mammals is admittedly scanty and inconclusive. For example, Ohno *et al.* (*3*) found evidence in the mouse for somatic association of the X chromosomes in epithelial cells of ovarian follicles and the mammary gland, but not in other types of cells that were examined. A possible way out of the dilemma is suggested by two important observations that have come to my attention. They demonstrate, at any rate, that the precise relationship between the sex chromatin and chromosomes is an unsolved problem that challenges the resources of cytologists.

Kosin and Ishizaki (*4*) showed that the presence of sex chromatin in somatic-cell nuclei is a female characteristic in the domestic chicken. Since the female is here the heterogametic sex, the sex chromatin cannot in this instance be a derivative of homologous sex chromosomes. Further, it is stated that the sex-chromatin complex for the female chicken is ZO (*5*). It seems, on this basis, that the sex chromatin in fowl is a derivative of the single Z chromosome, unless it bears no direct relationship to the sex-chromosome complex.

Related to the foregoing observation is the study by Ohno *et al.* (*6*) on nuclei of regenerating liver in the rat. A distinctive chromocenter was seen in interphase nuclei of females but not of males. In prophase nuclei, neither the X nor the Y chromosome of the male seemed to demonstrate positive heteropycnosis. But in prophase nuclei of females the surprising observation was made that one X chromosome was positively heteropycnotic while the other X chromosome was isopycnotic with respect to the autosomes. Ohno and his collaborators suggest that the positively heterochromatic X chromosome may be of paternal origin. It was folded back on itself in early prophase nuclei; this could explain the occasional clearly bipartite appearance of the sex chromatin. Ishizaki (*7*) states that a bipartite structure has also been detected in the sex chromatin of the chicken.

Confirmation of this work, and particularly its extension to the nuclei of man, would be of first importance in interpretation of the chromatin pattern and sex-chromosome constitution of patients with anomalies of sex development. Exact knowledge of the basis of nuclear sexual dimorphism is also needed for an explanation of the female chromatin pattern that is found in some teratomas in male hosts (*8*). We are now passing from the descriptive to the more difficult analytical phase in the study of the sex chromatin. The work of cytogeneticists and students of chromosome morphology is likely to play a decisive role in establishing the basis of sexual dimorphism in interphase nuclei.

MURRAY L. BARR
Department of Microscopic Anatomy, University of Western Ontario, London, Canada

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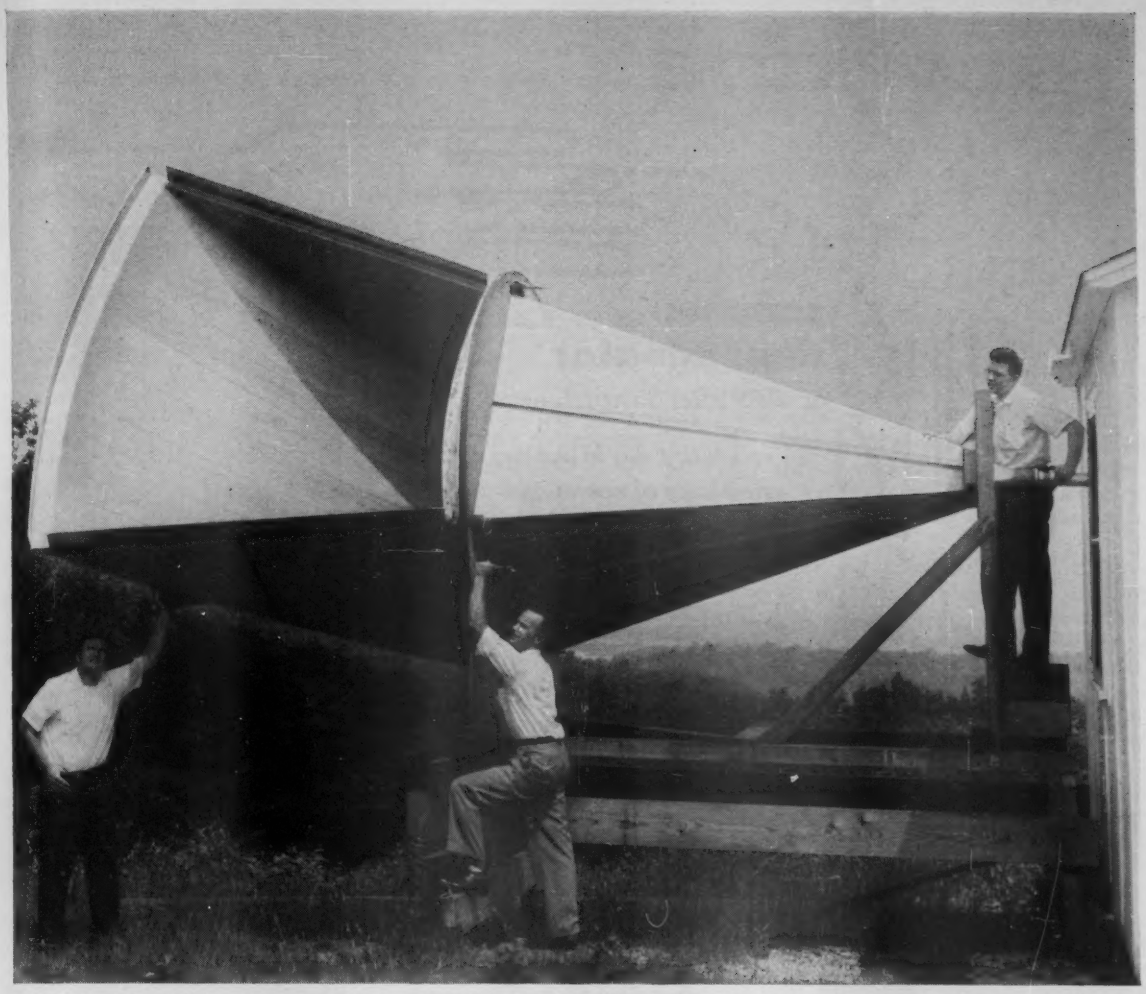
Position of the Catholic Church

It is very distressing to a scientist who is a Catholic to see in your columns a review such as that given by M. Edward Davis to Sulloway's *Birth Control and Catholic Doctrine* [*Science* **130**, 559 (1959)]. This distress comes *not* from the fact that Sulloway, Huxley, and Davis agree that contraception is the best method of controlling the birth rate—a position with which I heartily disagree—but from the fact that evidently neither Davis nor the editors of *Science* understand the basis upon which a review of such a work must be written.

Assuming that Davis has correctly presented the facts as assembled by Sulloway, it is also evident that Sulloway is too deficient in philosophical and theological background to have undertaken the task he set himself. This, of course, is not the responsibility of Davis or of the editors of *Science*. It is your responsibility to see that your reviews do not give a distorted picture of the situation. In what follows I shall concern myself solely with the review.

The first question that must always be considered in reviewing a book like

(Continued on page 1362)



At Bell Laboratories, Holmdel, N. J., a horn reflector antenna is beamed skyward by scientists Edward Ohm, David Hogg and Robert DeGrasse. The maser amplifier, which employs a ruby cooled in liquid helium, is inside building at right. Over-all "noise" temperature of antenna, amplifier and sky is only 18°K at 5600 megacycles.

ANOTHER STEP TOWARD SPACE COMMUNICATIONS

The above antenna is part of a new ultra-sensitive radio receiving system under development at Bell Telephone Laboratories. It has extraordinary directivity. Beamed skyward, it ignores radio "noise" from the earth, yet picks up extremely weak signals from outer space.

The signals are amplified by the latest Bell Laboratories "maser" amplifier. The maser principle was first demonstrated, using gas, by Prof. C. H. Townes and his collaborators at Columbia University. Bell Laboratories scientists applied it to the solid state guided by a theoretical proposal of Prof. N. Bloembergen of Harvard University. Their latest traveling wave maser amplifier employs a ruby mounted in a waveguide. The ruby is excited to store energy. As signals pass through, they absorb this energy and are thus amplified. The device uniquely combines the characteristics needed for practical space communication: extremely low inherent noise and the ability to amplify a broad frequency band.

At present the receiving system is being used to pick up and measure minute radio noise generated by the atmosphere. It also foreshadows important advances in long distance communications. For example, it could extend the range of space-probe telemetering systems, could help make possible the transatlantic transmission of telephone and TV signals by bouncing them off balloon satellites—and has numerous applications in radio astronomy and radar.

This pioneer development in radio reception is one more example of the role Bell Laboratories plays in the pursuit of better communications technology.

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13 November 1959, Volume 130, Number 3385

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They Have Troubles, Too

The reductions, cutbacks, limitations, and stretch-outs that scientists suffer at the hands of the people who prepare the federal budget are well known. There is another side to the coin, however. Scientists give the controllers a hard time as well. Controllers are suffering from an embarrassment of riches, not of money but of projects to spend it on. What the unceasing flow of wonders from science means to the fiscal experts is that one year's appropriation, even if adequate, is not necessarily at the best level for the next year's appropriation. For, as a scientific idea grows through the stages of research and development, so do the costs of advancing it further.

Consider, for example, the history and plans of the National Aeronautics and Space Administration. Its 1960 budget was pared to the bone by the administration, and the bone then gnawed clean by Congress. Yet, as the directors of the program have warned, this budget is just the beginning of what should be a series of budgets, each considerably larger than its predecessor. The case of the space agency is hardly unique. This is just one of a number of expanding programs, all competing for funds with each other and with a host of new candidates for government support.

The controller's woes run deeper still. Research and development is not just a matter of little acorns growing into mighty oaks. Though scientists hope for a good crop, they do not know for sure of what it will consist. Consequently, projects are difficult to classify, and a set of categories suitable at one time may not be suitable at another. Should one ask, what's in a name, the answer is, a great deal. Projects are administered by departments, bureaus, agencies, and offices. Where a project is placed may well affect, or be affected by, both the interpretation of its purpose and the kind of support it receives.

To continue the illustration from space science, President Eisenhower recently ordered the transfer of the Army Ballistic Missile Agency, which now devotes much of its energy to developing the super-rocket engine Saturn, to the civilian space agency. The order, regarded as sound by many observers, becomes effective next spring, unless opposed by Congress. Designed for space exploration, the engine, with its 1.5 million pounds of thrust as opposed to the 360,000 pounds of thrust of the Atlas intercontinental ballistic missile, has no immediate military use. It is more powerful than it need be to deliver present military payloads. In a few years, however, military applications for the rocket may develop, and aspects of the program may once more be classified as defense expenditures.

The trouble that scientists and fiscal experts make for each other is an annual affair, and this is the season when the struggle quickens. The administration's budget for 1961, now taking final shape, will be presented to Congress when it reconvenes in January. How, then, fares this year's battle? In considering the plight of fiscal experts, we certainly agree that for so fertile a union as that of science and government, planned parenthood is necessary. But with an economy-minded administration entering what will be the last complete year of its record, over-all prospects for research and development are not good. The immediate danger is too much control and too few offspring.—J.T.

13 November 1959, Volume 130, Number 3385 SCIENCE

National Radio Astronomy Observatory

The early history and development of the observatory at Green Bank, West Virginia, are reviewed.

Richard M. Emberson

On 17 October 1957, a group of several hundred representatives of science, education, and federal, state, and local governments gathered in the high-school auditorium at Green Bank, West Virginia, to participate in ground-breaking ceremonies for the National Radio Astronomy Observatory. This event followed by two weeks the launching of the first artificial satellite, on 4 October, and in some minds the Green Bank activities were an indication of the immediate reaction of the United States to this tremendous step into the space age. The near coincidence of these dates is interesting, but no significance should be attached to it. The ground-breaking ceremonies at Green Bank were only one step in a long train of events which hark back to the discovery of radio astronomy by Karl G. Jansky in 1932.

Early History

Accounts of Jansky's discovery have been recorded on numerous occasions (*1*). In brief, Jansky was studying the effects of atmospheric radio interference on transatlantic communications at the Holmdel, New Jersey, station of Bell Telephone Laboratories, when he noticed certain signals with peculiar characteristics that could be explained only if they were originating from outside the earth's atmosphere in a direction fixed in space. Jansky's equipment (Fig. 1), which operated at 14.6-meter wavelength, was not capable of extreme directional precision, but Jansky was able to fix the position of this celestial radio transmitter in the sky at roughly 18 hours of right ascension and $-10°$ declination, which is approximately toward the center of our own galaxy or Milky Way system.

Little attention was paid to Jansky's discovery by professional astronomers, and throughout the 1930's the only continuing activity in this new branch of astronomy was carried on by Grote Reber, operating equipment designed and built by himself at his home in Wheaton, Illinois (Fig. 2). Reber's results were published in a series of papers that clearly showed the existence of sources of radio interference or static in the plane of our Milky Way (*2*).

During World War II, tremendous strides were made in developing electronic components, particularly for radar, and during this time the sensitivity of the receivers for such equipment was improved greatly over that of the receivers available to Jansky and Reber. Throughout the war years numerous persons, by chance or otherwise, made astronomical observations, but time was not available to pursue an orderly investigation of the astronomical phenomena (*3*). When hostilities ended, however, scientists returned to examine these phenomena, and by the late 1940's, centers of radio astronomy had been established in several countries, including particularly England, the Netherlands, France, Australia, Canada, and the United States. Scientists behind the Iron Curtain were also interested in this new branch of astronomy, but their areas of activity and interest were not immediately known to us in the United States.

During the occupation of the Netherlands in World War II, a young Dutch radio astronomer, H. C. van de Hulst, predicted from theoretical considerations that a radio emission at a wavelength of approximately 21 centimeters should be produced by the neutral hydrogen in our galaxy with sufficient intensity that it could be observed with equipment then deemed feasible. The first observations of this hydrogen radiation were made by H. I. Ewen and E. M. Purcell at Harvard University (*4*). Because hydrogen is the most abundant element in the universe, this observational confirmation of van de Hulst's prediction was of great significance, because, essentially, a signature had been found amid all the random noise or static coming to us from outer space. For readers more familiar with the optical portion of the spectrum, it should be noted that the 21-centimeter hydrogen emission is analogous to the absorption lines in the solar and stellar spectra, which are also identified with chemical elements on the earth.

This impetus to astronomy had prompt effects in a number of countries. The British, spurred on by A. C. B. Lovell, had started to build a radio telescope with a steerable paraboloid 250 feet in diameter. They recognized the significance of the hydrogen radiation and forthwith proceeded to revise the design for the giant telescope at Jodrell Bank in order that it might be used to make observations at this rela-

The author is assistant to the president of Associated Universities, Inc., New York, N.Y., and acting deputy director and director for construction of the National Radio Astronomy Observatory, Green Bank, W. Va.

tively short wavelength. In the Netherlands, work was started on a 25-meter telescope, and in Australia preliminary plans were initiated for the design of a large steerable paraboloid. Meanwhile, in the United States, the 50-foot telescope of the Naval Research Laboratory was the only large instrument capable of efficient work at wavelengths as short as 21 centimeters. Other institutions, including Cornell University, Harvard College Observatory, the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, and Ohio State University, had active programs in radio astronomy, but none of these institutions were planning construction of a steerable paraboloid larger than the 50-foot instrument at the Naval Research Laboratory.

This was essentially the state of affairs in January 1954 when a conference was called in Washington, jointly sponsored by California Institute of Technology, the Carnegie Institution of Washington, and the National Science Foundation (*5*). This conference was called to take advantage of the presence in the United States of several distinguished radio astronomers from other countries. At the conclusion of the conference it became clear to the United States scientists that radio astronomy in the United States was not keeping up with progress being made in other countries, and that unless this trend were reversed, the United States would drop further and further behind, into a most unsatisfactory, secondary position. This state of affairs was all the more deplorable in view of the noteworthy contributions from the United States: Jansky's discovery of radio astronomy; Reber's exploratory observations; advances in electronic technology; and the first observation of the 21-centimeter hydrogen emission by Ewen and Purcell. There was general agreement that the principal need in the United States was for improved observational equipment having capabilities at least as good as those that were already, or soon would be, available in other countries.

At this point the National Science Foundation (*6*) entered the picture. The foundation is a unique agency in the federal government. It was founded by an act of Congress in 1950 to insure that science would have proper attention at the federal level of government, and, particularly, to provide a mechanism for supporting those areas of science in which it appeared that the United States was lagging behind other countries. Within the foundation the plight of the United States radio astronomer was recognized, and in order to provide a mechanism for giving more attention to the problem, an advisory panel for radio astronomy was established, in May 1954, with M. A. Tuve serving as chairman.

During that spring there were discussions among radio astronomers in the United States on the pressing problem of obtaining better observing facilities. Some colleges and universities decided to build radio telescopes as part of their academic establishments. Other institutions tentatively suggested pooling their efforts, thereby making possible the construction of larger, more costly facilities than could be afforded singly. During such discussions between B. J. Bok, J. B. Weisner, J. P. Hagen, and other representatives of Harvard, Massachusetts Institute of Technology, and the Naval Research Laboratory, Julius A. Stratton suggested the establishment of a radio observatory to be operated on behalf of all United States scientists; a somewhat analogous research institution was already in existence at the Brookhaven National Laboratory, which is operated by Associated Universities, Inc., under contract with the Atomic Energy Commission (*7*). The Brookhaven National Laboratory is essentially a postgraduate research center active in all domains of science related to nuclear energy. A permanent staff of scientists is augmented by visitors who come for terms varying from a few weeks to as much as a year or more.

Acting on Stratton's suggestion, a group of scientists directed informal inquiries to Associated Universities, seeking assistance in bringing the matter to a point at which a decision could be made on the feasibility of establishing such an observatory. A conference was held in New York on 20 May 1954, attended by representatives of astronomy and other closely related fields of science and engineering, at which this question was formally raised, in a memorandum, "Survey of the Potentialities of Cooperative Research in Radio Astronomy," prepared on 13 April 1954 by D. H. Menzel, director of Harvard College Observatory. The conference concluded that a three-step program was in order, involving: (i) a feasibility study on objectives and organization, sites, and facilities; (ii) final design of facilities and equipment; and (iii) construction of the observatory. The National Science Foundation representatives agreed with the others present that a national observatory would solve many of the problems confronting workers in radio astronomy in the United States, and a tentative commitment was made on behalf of the foundation to support a feasibility study on the establishment of such an observatory. On the basis of the 20 May conference and subsequent discussions with Menzel and Tuve, L. V. Berkner, president of Associated Universities, organized a steering committee for a feasibility study; John P. Hagen served as chairman, and other members were

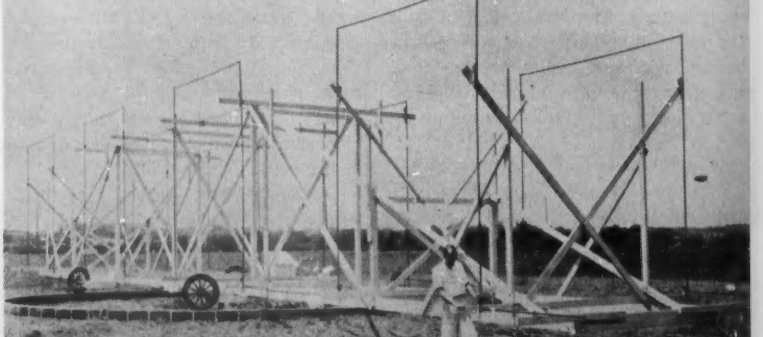

Fig. 1. Karl G. Jansky and his 14.6-meter rotatable directional antenna. The important discovery that some stars produce radio waves was made by Jansky, a Bell Laboratories scientist, while he was exploring atmospheric disturbances which it was thought might interfere with transoceanic telephone service. His discovery, in 1932, marked the birth of the fast-growing science of radio astronomy. [Courtesy Bell Telephone Laboratories]

Bart J. Bok, Armin J. Deutsch, Harold I. Ewen, Leo Goldberg, William E. Gordon, Fred T. Haddock, John D. Kraus, Aden B. Meinel, Merle A. Tuve, Harry E. Wells, and Jerome B. Weisner. Throughout the feasibility study the steering committee gave valuable assistance and advice. During the second year of the study, Bart J. Bok served as chairman of the committee.

Meanwhile, the trustees of Associated Universities had authorized the expenditure of $2000 to defray preliminary expenses, and this made possible a meeting of the steering committee in July 1954. The committee reviewed a research proposal, to be made to the National Science Foundation for a grant to support the feasibility study. The principal objectives of the study were as follows: to make (i) a survey of opinion among scientists who are now active or interested in the field of radio astronomy, in order to set up a program of research objectives; (ii) an examination of the various suggestions made regarding the major items of equipment, to gain some understanding of the technical problems of design and construction that would have to be solved, and to be able to compare performances and costs; (iii) an examination of possible sites and their comparative desirability, judged by the requirements of the research program and staff, the availability of housing and transportation, meteorological factors, sources of radio interference, accessibility to other centers of intellectual activity, and any other factors shown to be important by the first two parts of the study; (iv) an examination of any other expenditures essential to the establishment of a functional radio astronomy observatory—for example, access roads, power lines or power generating equipment, and laboratory buildings; (v) preliminary estimates of the costs involved in phase ii, preliminary proposals of methods to finance these costs, and consideration of how much time to allow for completing this phase; and (vi) preliminary estimates of the organization and staff necessary to operate the completed facilities and proposals on budgets, personnel policies, and methods of promoting cooperation among interested institutions.

On 18 February 1955, the National Science Foundation granted $85,000 to Associated Universities to support the feasibility study, and active work started. I served as principal investigator or project director.

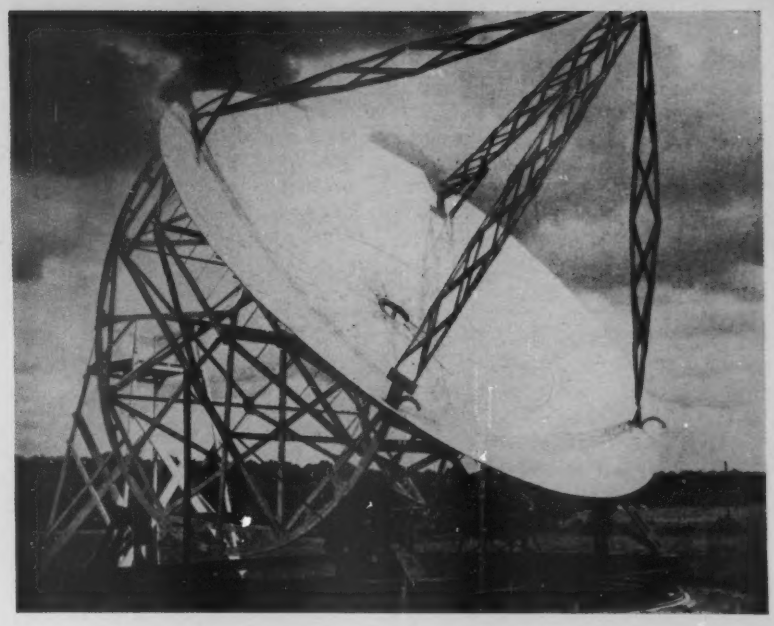

Fig. 2. The Reber telescope. Grote Reber designed and built this telescope at Wheaton, Illinois, soon after the announcement of Jansky's discovery. The telescope was moved to the National Bureau of Standards in the early 1940's, where this photograph was taken by Reber.

The study efforts were channeled into three areas: (i) organization and operation; (ii) facilities; and (iii) site. All of these obviously would be affected by the research objectives for the observatory. In order that this question might be crystallized promptly, early in the spring of 1955 B. J. Bok contacted all of the United States scientists engaged or interested in radio astronomy, and from their comments developed a statement of research objectives. It was recognized that the observatory should provide facilities for research at long wavelengths; on the other hand, it was recognized that research tools for short wavelength were more costly, and that these, particularly, should be made available.

It was agreed that research at 21-centimeter wavelength should be pursued at the observatory, with radio telescopes having high gain and resolution, and that such research should include studies of the structure of our own and other galaxies, the hydrogen clouds associated with peculiar stars, globular clusters, and absorbing clouds of dust, as well as measurements of the Doppler red shift. Early work by F. T. Haddock and his colleagues at the Naval Research Laboratory had revealed the possibility of making thermal emission studies throughout the microwave region. A critical problem was that of spectral classification of radio sources, based on measurements of the radio brightness at a number of wavelengths distributed over as wide a band as possible. Many research problems were suggested for learning more about the solar system. For some studies of the moon, planets, and sun, only receiving equipment is necessary; other studies require that the radio telescope be fitted as a radar, capable of transmitting as well as receiving.

From these considerations, the steering committee proposed that a series of steerable paraboloid telescopes be planned for the observatory. First in this series was to be an instrument (of 140-foot diameter, it was subsequently decided) with very high precision in its reflector surface, in its position indication, and in its capabilities for tracking celestial objects. The consensus was that such a precision instrument would be the most satisfactory all-purpose research tool. The committee felt that the observatory should also have an active instrumentation program, covering antenna theory and design, electronic tubes and other components, receivers, and information theory and data handling.

Underlying these research programs was a basic question of organization.

Should the observatory be a self-sufficient institution, or should it be divided, with its laboratory and supporting facilities located in some urban center and with only the observing equipment and a minimum of supporting facilities located at a remote site? Examples of this latter arrangement are quite common among optical observatories; for example, the Pasadena office and laboratories of the Mount Wilson and Palomar observatories, and the Tucson laboratory of the recently established Kitt Peak National Observatory. On the other hand, there are examples of self-sufficient observatories, both optical and radio. The probable isolation of the new observatory and the objective of continual interplay between the laboratory and the observing programs turned the decision in favor of a self-sufficient organization.

The organization of the observatory, its transition from a construction phase to an institution actively engaged in research, and the results of these researches are not treated in this article. It suffices to mention that Otto Struve has been appointed the first director. A permanent staff has been slowly built up, and these scientists, plus visitors, have carried on various astronomical observational researches since early in 1959. The prospects are bright for realization of our hopes for the National Radio Astronomy Observatory.

Site

The steering committee listed eight specifications for the site.

1) *Radio noise.* The level of radio noise or interference on wavelengths below 10 meters (frequencies greater than 30 megacycles per second) must be extraordinarily low. The fundamental sensitivities to which the radio telescopes can operate on any frequency are directly proportional to the ratio of external noise to desired signal. Therefore, the usefulness of the site is directly proportional to the amount of interference noise. To avoid noise the following conditions are necessary: (i) the number of inhabitants close by, within "view" of the telescopes, who might generate noise in the course of their daily work, should be as small as possible. (ii) The telescopes should not "view" high-tension power lines, which radiate radio noise through corona discharges or other means. (iii) The site should be in a valley surrounded by as many ranges of high mountains in as many directions as possible, to attenuate direct radio propagation from neighboring radio stations and to reduce diffraction of tropospheric propagation into the valley. (iv) The site should be at least 50 miles from any city or other concentration of people or industries and should be separated from more distant concentrations by mountain ranges. (v) The site should not be near commercial air routes, with aircraft frequently flying over, or in a region where commerce or industry are likely to intrude and grow in the future.

Quietness of the site must be assured for the future—for example, by appropriate zoning regulations to permit control over the installation and use of equipment, devices, or systems of any type that might emit radio noise.

2) *Location south.* The site should be as far south as possible, with a southern obstruction not exceeding a few degrees, to permit observation of the center of the Milky Way and other objects having southern declinations. A site anywhere in the United States could view all celestial objects in the northern celestial sphere but not all celestial objects in the southern celestial sphere. The more southerly the site, the more of the sky it can view.

3) *Location north.* The site should be in northern latitudes to permit researches that involve auroras, ionospheric scintillation, and polar blackouts.

4) *Ice and snow.* The site should not be in an area of excessive snow and ice that would create great snow and ice loads on the radio telescopes. Snow and ice need not be entirely absent, but they should be at a minimum to prevent excessive "down-time" of radio telescopes.

5) *Winds.* The site should not be in a region subject to violent winds and tornadoes. Because telescopes have large exposed areas, it is very difficult or impossible to construct them to withstand tornadoes or hurricanes. Moreover, strong winds are usually accompanied by periodic gusts of such force that they might cause dangerous vibration in large structural units.

6) *Humidity.* The climate should be reasonably mild, and high humidity is undesirable. Since the radio telescopes operate in the open, maintenance during excessively long cold periods becomes difficult and introduces problems of operation. Moreover, high humidity speeds the physical deterioration of materials and increases problems of electrical insulation.

7) *Size.* The site should be large enough to allow adequate separation among the installations of many types and sizes of telescopes and arrays; the latter require a relatively flat space of 1 or more square miles. A total area of as much as 5000 to 10,000 acres should be available for eventual use by the observatory.

8) *General surroundings.* Within the limits set by the basic requirements, the site should provide as many as possible of the attributes of a university campus. These include, of course, the physical means for research—laboratories and shops, libraries, and conference rooms. It would also be stimulating and helpful if scientists working in related domains of science were nearby—mathematicians, engineers, chemists, and physicists, to name only a few.

The site should provide or be accessible to housing and other necessary facilities for visiting scientists and for the permanent staff and their families. In addition, access to other amenities, such as stores, theaters, and recreational areas, is desirable.

Within the limits of the basic requirements, the site should be easy to reach by plane, rail, or automobile.

A ninth specification was added by the National Science Foundation's advisory panel on radio astronomy—namely, that the initial search be limited to within about 300 miles of Washington, D.C.

Some of the specifications are mutually contradictory or incompatible. It was therefore necessary to attach an index of importance to each. Beyond all question, the most important specification is the level of radio noise or interference at the site. Throughout all of the discussions about the site there was a strong sense that more was involved than merely the selection of a location for the new observatory. It could be foreseen that an excellent site would be a national asset that would become more valuable with the passage of years, *provided* that means could be promptly initiated to reduce, or at least to hold to the present levels, radio interference from man-made sources. Indeed, radio astronomers located near urban centers find that the present levels of interference forbid many relatively simple experiments. The steering committee envisaged a situation in which these scientists could move their apparatus to the observatory site and

Fig. 3. Helicopter view of the central portion of the National Radio Astronomy Observatory site, looking eastward from above the location for the 140-foot telescope. The 85-foot Howard E. Tatel telescope appears in the distance, and at the far right the works area and the incomplete residence hall and laboratory buildings may be seen. [Naval Radio Research Station, Sugar Grove, W.Va.]

proceed with their researches because of the low levels of interference, without using costly facilities of the observatory. With this potential use of the observatory site in mind, one finds a deeper significance in the specification for the size of the site.

The search procedure was relatively simple at the outset. The risk of hurricane-wind damage to the large radio telescopes eliminated the Atlantic coastal area from consideration. The U.S. Weather Bureau furnished data on all tornadoes recorded in the period 1916-1950. These data show that few tornadoes have occurred in a large region from northern Maine, through north and central New York, north-central Pennsylvania, and an oval-shaped area, about 300 miles long and 100 to 150 miles wide, extending in a southwest-northeast direction from eastern Kentucky and Tennessee, through West Virginia and the western edge of Virginia, almost to the Pennsylvania border. Of these relatively tornado-free regions, all but the last was eliminated because of problems of winter ice and snow, and because of distances of more than 300 miles from Washington, D.C.

The search area, thus limited, is characterized by mountain ridges that run in a general northeast-southwest direction. A wide valley or cove among these mountains would thus offer a site having many of the desired characteristics. In particular, the rough mountain terrain would guarantee a relatively low density of human population and, hence, of man-made radio interference. Furthermore, the mountains would serve as partial shields against some more distant sources of man-made interference, and against winds.

An *ad hoc* panel was organized, composed largely of persons having some direct knowledge of the search area, as well as an interest in the proposed observatory. Members of the *ad hoc* panel were H. L. Alden, J. E. Campbell, C. E. Cutts, E. R. Dyer, R. M. Emberson, H. I. Ewen, F. T. Haddock, J. P. Hagen, William Hardiman, R. A. Laurence, William McGill, W. A. Nelson, P. H. Price, C. K. Seyfert, and P. van de Kamp.

This *ad hoc* panel compiled a list of more than two dozen possible sites. Independent inquiries were also addressed to the U.S. Forest Service, the U.S. Park Service, the Geological Survey, the Tennessee Valley Authority, the Army Map Service, and the Real Property Disposal Office of the U.S. General Services Administration. Through the early stages of the search there was some hope that a suitable site could be found on land already owned by the federal government. This hope faded and died because the search showed that any oasis of relatively flat land had been discovered by settlers more than a century earlier, and that all these coves and valleys have been in private hands for many years.

Finally there were 30 site possibilities that seemed worthy of closer examination. Many were eliminated by visual inspection, usually because of existing urban and industrial centers close by.

The five most promising sites were then subjected to a careful and detailed study. Counts were made of the total population within 20-mile and 50-mile radii for each site. Studies were made of existing and planned air ports, air lanes, and related aviation installations. The American Telephone and Telegraph Company supplied information on existing and planned installations that might raise the radio noise levels nearby. Finally, arrangements were made with the Naval Research Laboratory whereby suitable receiving equipment was made available to engineers of Jansky and Bailey, Inc., for the purpose of making radio-noise measurements. The data from these measurements were sufficient to permit assignment of a relative number or index for interference levels at the five sites.

On the basis of these detailed studies, the 18th possibility on the list, at Green Bank, West Virginia, stood out. The radio-interference measurements showed that the Green Bank site was in a class by itself. Also, it was first on the basis of the population studies and first on the basis of the location of nearby towns and cities, and it was tied for first on the basis of aviation activities.

The Green Bank site area (Fig. 3) consists of a triangular portion of Deer Creek valley, about 4 miles across at the southern base and extending about 3 miles northward. The average elevation is 2700 feet above sea level. Mountains rise in multiple folds in all directions, many to heights of 4000 feet.

The village of Green Bank, from which the site gets its name, is situated in Pocahontas County. The largest urban center is Marlinton, the county seat, which is about 30 miles to the south. Green Bank is slightly more than 200 miles west of Washington, D.C., about midway between Roanoke, Virginia, and Pittsburgh, Pennsylvania, and about 170 miles east of Charleston, West Virginia.

The steering committee unanimously recommended the selection of the Green Bank site for the proposed observatory. The committee further urged that nearly all of Deer Creek valley at Green Bank be acquired, to insure better local protection against interference, or, if direct purchase of all the land was not feasible, that suitable controls be arranged to insure continued suitability of the site for the National Radio Astronomy Observatory.

The National Science Foundation adopted the steering committee's recommendation and authorized Associated Universities to obtain purchase options. These were obtained by Richard F. Currence, of Marlinton, acting on behalf of Associated Universities. By mid-spring of 1956 he had about 6000 acres under option. Purchase of more land had been recommended by the steering committee, but to have sought additional options would have required price agreements that seemed unreasonable, and the option program was halted.

After completion of the contract between Associated Universities and the National Science Foundation, in November 1956, for the establishment and operation of the observatory, one of the first tasks was site procurement. It was decided to let the options lapse and to arrange for the U.S. Army Corps of Engineers to acquire the site on behalf of the foundation and the federal government. This decision brought an agency with vast experience in land problems to the important task of acquiring the site. The valley was divided into regions or zones, and the Corps of Engineers was instructed to start acquisition proceedings in the central zone and work outward until a total expenditure of about $550,000 had been made. At that stage, no more land was purchased. The site, thus determined, consists of about 2700 acres, bounded on the east by state route 28 and the villages of Green Bank and Arbovale, on the south by a ridge that extends southwest from Green Bank, and on the west by the irregular boundary of the national forest lands.

At the same time that the option program was initiated, steps were taken to protect the site from future encroachment of man-made noise. Through the good offices of Arthur D. Little, Inc., contact was made with the governor of West Virginia, William Marland, and he and members of his staff were briefed on the proposed observatory. The West Virginia officials were favorably disposed toward the plan, and they thought that a zoning act could be drafted that would give the observatory protection against the encroachment of local, unlicensed sources of radio interference. West Virginia legislative leaders were briefed on the problem, drafts were discussed and revised, and a special session of the Assembly and Senate convened on 9 August 1956. The legislature enacted the Radio Astronomy Zoning Act, which to the best of our knowledge is the first legislation anywhere in the world designed explicitly to protect research in radio astronomy and allied sciences.

This special zoning act also protects the naval station at Sugar Grove, West Virginia, located a little more than 30 air miles east and north of Green Bank. The observational environment desired by the Navy at Sugar Grove is similar to that desired for the National Radio Astronomy Observatory, and the two groups have worked closely together in seeking to eliminate or reduce the levels of radio interference from man-made sources.

The West Virginia zoning act is directed toward unlicensed, local sources. The Federal Communications Commission has jurisdiction over licensed, intentional transmitters. (Within the federal government, the Interdepartmental Radio Advisory Committee plays a regulatory role among federal agencies that is analogous to the relationship of the Federal Communications Commission to commercial broadcasters.) The special radio-noise problem at Green Bank and Sugar Grove was taken to Washington. After thorough hearings and several reviews had been completed, special rules were promulgated to establish a radio quiet zone for both Green Bank and Sugar Grove. This quiet zone is rectangular in area, approximately 100 miles across in the east-west direction, and 120 miles from north to south. The special rules provide that civil applications for new or revised transmitters in the quiet zone shall be brought to the attention of the director of the National Radio Astronomy Observatory, who is responsible for bringing the matter to the attention of the Navy at Sugar Grove and submitting a coordinated reply or comment to the Federal Communications Commission. (In the case of applications by a governmental agency, the case is handled between Green Bank and Sugar Grove by the Navy.) To date, this arrangement seems to be working smoothly.

Radio astronomers know aircraft can seriously interfere with the work at Green Bank. A metal airplane without any electronic equipment on board can serve as a mirror to reflect into the radio telescopes signals from ground stations that otherwise would be shielded by the mountain ridges. When the nearby aircraft is equipped with electronic equipment, including beacon,

navigational, and other types of transmitters, the situation becomes quite serious. The primary emissions from such nearby transmitters completely mask any celestial radio signals at the same frequency. In addition, spurious emissions, which may be at frequencies above and below those of the primary emissions and which are of such low intensity as to be of no consequence in normal communications and navigational applications, are frequently of the same order of magnitude as the celestial signals sought by the astronomers. The hydrogen emission at 21 centimeters, or 1420 megacycles per second, and the lower frequencies that result from a Doppler red shift, unfortunately lie in a band assigned to aviation purposes. Thus, for example, the spurious signals from aircraft flying in the neighborhood of Green Bank will interfere with this important astronomical observing band, even if the aircraft transmitter's primary frequency is carefully set away from the hydrogen frequency. Because of this situation, Associated Universities has asked the National Science Foundation to seek some measure of protection against aircraft interference at Green Bank.

Since the first observation of hydrogen emission by Ewen and Purcell, radio astronomers have recognized that they were the receiving station for a peculiar type of communication system. If both man-made transmitters and receivers were used by the scientists, they could apply for a license that would assign a frequency for the experimental work. In the case of radio astronomy, including also many branches of geophysics, the transmitter is a natural phenomenon, emitting at frequencies independent of man and his neat allocations and assignments. Hence, a normal type of communication license is not helpful to the research programs, unless it is carefully written to coincide with the frequencies of the natural emitters. Essentially such a special research license has been and is being sought by several groups representing radio astronomers and allied scientists. For a number of years both the International Astronomical Union and the International Scientific Radio Union have urged that special frequency bands be assigned for research purposes. In the United States, the Federal Communications Commission has recommended, in docket No. 12263, that the 1400-to-1427-megacycle-per-second frequency band be reserved internationally for radio astronomical use.

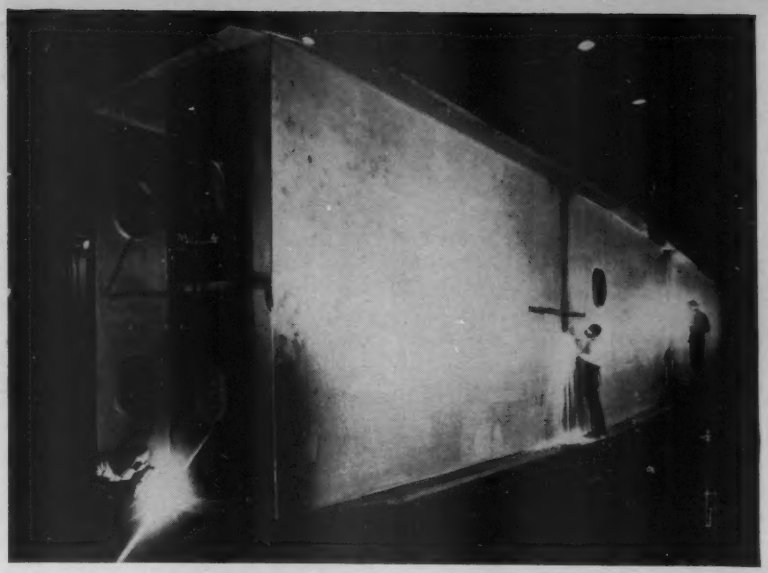

Fig. 4. Fabrication in the Bliss plant of part of the yoke for the 140-foot telescope. [E. W. Bliss Company]

This matter also found its way to the 9th Plenary Assembly of the International Radio Consultative Committee, meeting in Los Angeles during April 1959. The committee adopted the following recommendation (Docket No. 437-E [revised]): (i) that radio astronomers should be encouraged to choose sites as free as possible from interference; (ii) that administrations should afford all practicable protection to the frequencies used by radio astronomers in their own and neighboring countries; (iii) that particular care should be taken to give complete international protection from interference to observations of emissions known or thought to occur in the following bands:

Line	Line frequency Mcy/sec	Band to be protected Mcy/sec
D	327.4	322– 329
H	1420.4	1400–1427
OH	1667	1645–1675

(iv) that the bands allocated for standard frequency and time signal emissions at 2.5, 5.0, 10.0 and 20.0 megacycles per second should not include anything other than the standard frequency and time signal emissions, their use for reception in radio astronomy thus being permitted; (v) that consideration be given to securing adequate international protection of a number of narrow-frequency bands throughout the spectrum above 30 megacycles per second for the purpose of reception in radio astronomy (*8*); and (vi) that administrations, in seeking to afford protection to particular radio astronomical observations, should take all practicable steps to reduce to the absolute minimum amplitude harmonic radiations falling within bands of frequencies to be protected for radio astronomy.

To become effective, these recommendations must be adopted by the International Telecommunications Union. This treaty-making organization, in which the United States participates through an official delegation organized by the Department of State, is in session at Geneva as this article is being written. At Geneva, the requirements for scientific research are opposed by the pressures for allocations in the frequency spectrum to commercial, military, and other users. Obviously, an allocation of a portion of the frequency spectrum has great potential value, and the pressures at Geneva are correspondingly in evidence. It is understood that the U.S.S.R. favors the adoption of the International Radio Consultative Committee recommendations, but other nations are awaiting an indication of the United States' position. The official instructions of the United States delegation on this matter have not been made public. It is hoped that a strong, affirmative stand to protect basic research will be taken. The situation is critical because the International Telecommunications Union convenes only

at about 10-year intervals. If protective measures are not taken now, research in radio astronomy and allied sciences throughout many portions of the frequency spectrum will be doomed during the next decade.

Site Planning and Development

As part of the feasibility study, the New York firm of Eggers & Higgins planned the development of a typical site in order to bring some realism to the estimates of the work that would have to be done. After the site in West Virginia was selected, it seemed better to engage a firm more familiar with the local building situation. Accordingly, under its contract with the National Science Foundation, Associated Universities engaged the firm of Irving Bowman & Associates, of Charleston, West Virginia, to perform the necessary architectural and engineering work at Green Bank. It was made clear that the special technical problems related to the radio telescopes and other research equipment were not a part of the Bowman assignment.

Advantage was taken of a relatively high ridge that extends across the central portion of the site in a general east-west direction. A plan was developed whereby most of the observatory buildings would be located at the eastern end of the ridge, close to route 28. Radio telescopes of the steerable paraboloid variety would be placed further west along the ridge, thus minimizing through distance any interference from automobile traffic on the highway. An access road was designed and constructed along the central ridge.

The electric power distribution system found in the Green Bank area was marginal, even if no additional loads were added by the observatory. The Monongahela Power Company advised that long-range plans called for a complete revision and modernization of the system. This revision was accelerated because of the observatory's requirements. As this report is being written, a new 66-kilovolt line is being constructed along the Greenbrier River, approximately 7 miles west of the site. A substation will feed a 12-kilovolt branch that comes east to the observatory. Where this feeder line comes over the nearest mountain ridge within "view" of the radio telescopes, the normal line is replaced with shielded cable in order to minimize radio interference. A second transformer station, located on the east bank of Deer Creek and naturally shielded from the radio telescopes, will convert from 12 kilovolts to the 4160-volt power that is distributed through an underground conduit system, parallel to the observatory road. Transformers are provided at each telescope, building, or other major installation. The total observatory power requirements, including those of the 140-foot telescope (described in more detail below), have been estimated at slightly more than 1 megawatt. The system being installed by the Monongahela Power Company is capable of delivering 3 megawatts.

Water at Green Bank is obtained from wells, usually drilled to a depth of slightly more than 100 feet. The supply is modest by commercial standards but should be adequate for the normal observatory requirements. The complex of residence hall and cafeteria, laboratory, and works area or shop buildings is served by three wells that supply an elevated 100,000-gallon tank. This arrangement offers some degree of fire protection and is certainly capable of handling the normal daily peak loads.

Building Program

During the feasibility study, the steering committee reviewed the types of activities that would be carried on at the new observatory and recommended that four types of buildings be included in the site development plan. First was the obvious requirement for a control building, or its equivalent, for each radio telescope, to serve as a base of operations for radio astronomers and to house the electronic equipment required for the receivers and data storage and processing. Second, a laboratory building in combination with administrative offices would be needed. Third, construction of shops for maintenance of the observatory, as well as for the construction of special equipment, was deemed advisable; and fourth, housing was required, particularly for visiting scientists.

As the Army Corps of Engineers acquired the site, some farm houses became available for use. The first of these was remodeled as a field office and has been in use since May 1957. Other houses were converted to provide office space for the radio astronomers and laboratory space for the physicists and electronic engineers. Other houses were remodeled to serve as family dwellings, and the largest has served as a dormitory. All of these farm houses will probably continue to be used for housing for a number of years. It is entirely unreasonable to expect scientific visitors to the observatory to make personal investment in a residence, and when these visitors come with families too large to be accommodated in the rooms or apartments available at the new residence hall, the only possible solution is to have an individual residence available.

The hypothetical site development undertaken by Eggers & Higgins as part of the feasibility study included preliminary plans for the buildings at Green Bank. These preliminary plans were subsequently revised in accordance with more precise estimates of the requirements for the observatory. Portions of three buildings have now been completed at Green Bank. A decision was made to combine all of the maintenance shops, warehousing, and similar activities in one building, of which one wing would be of special construction with high, clear spans to permit work to be done indoors on large and bulky equipment. Budget limitations would not permit construction of this special wing in the initial phase of the program. This so-called "works area" building was completed in the fall of 1958. Immediately upon its completion, the research equipment development department, under John W. Findlay, moved into a portion of the building. A conference room, carpenter shop, machine shop, and stock room were also provided, in addition to the necessary boiler room, electric power center, and area for the maintenance of work vehicles at the site.

The laboratory building envisioned by the committee for the observatory will have a central section plus three wings. One wing is to accommodate the special laboratories required in the development of the electronic equipment required for the research programs. A second wing will consist of a large auditorium, and the third wing will provide accommodations for research astronomers, as well as large computer facilities. The central part will accommodate all the administrative offices, including the offices of the director and his immediate staff and offices of some of the research astronomers, the library, several conference rooms, and the miscellaneous requirements for the research establishment. For budgetary reasons, only the central section of the laboratory was included in the first phase of construction. This will be ready for

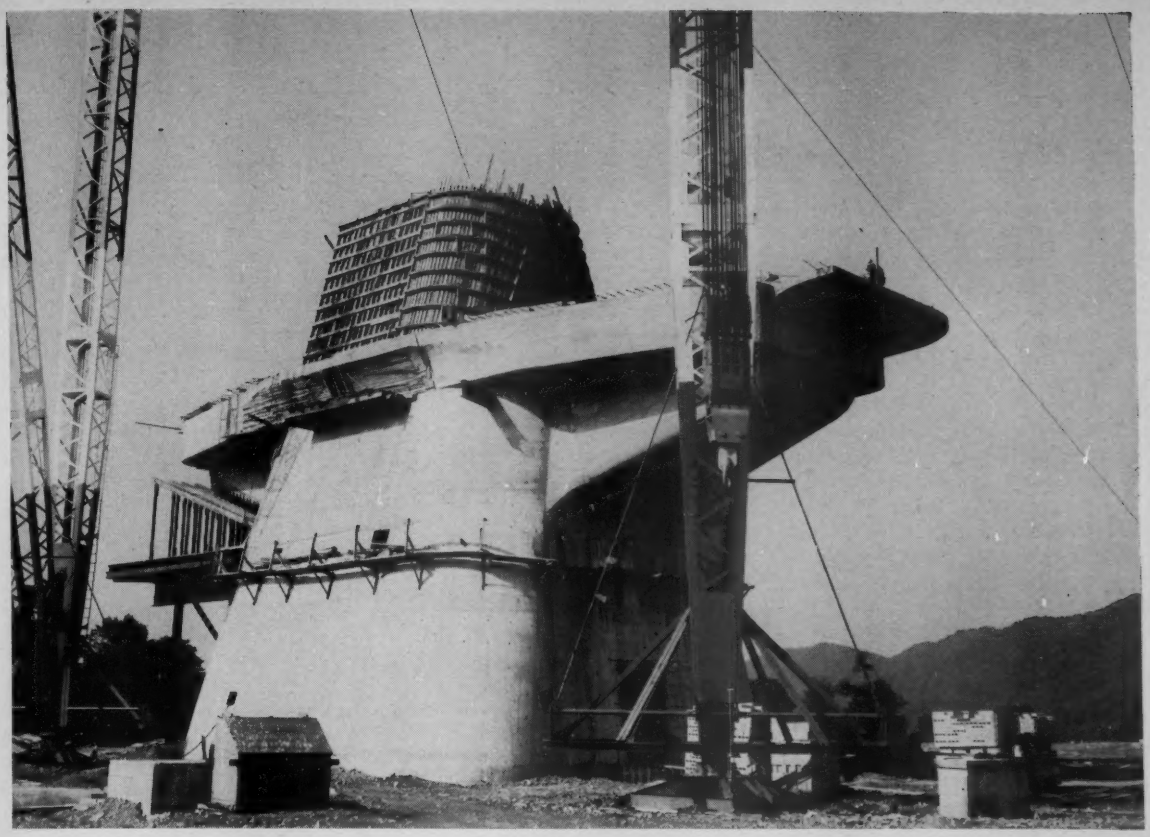

Fig. 5. View from the northeast of the nearly completed foundation for the 140-foot telescope. The two huge derricks will be used to lift the subassemblies of the telescope into position. [National Radio Astronomy Observatory]

occupancy early in the fall of 1959, when the research equipment development group will move from its temporary quarters in the works area building and will occupy most of the laboratory's first floor. A small engineering office concerned with the construction of the 140-foot telescope and with similar problems will also be housed on the first floor. On the second floor, Otto Struve will have his offices, adjacent both to the administrative department, under Frank J. Callender, and to the astronomy department, under David S. Heeschen.

The residence hall, which also will be ready for occupancy in the fall of 1959, provides four apartments on the first floor, together with a cafeteria that will be adequate to provide meals for the observatory staff, which, it is now estimated, will ultimately be something more than 100 persons. The second floor of the residence hall provides 16 bedrooms, each with an individual bath. It is planned that each of these rooms will be occupied by a single individual, but they are large enough to accommodate two people at times of special meetings and symposia. The ultimate plans for the observatory provide for at least twice this much residence hall space, as well as for additional residences to supplement the renovated farm houses.

Telescope Program

The feasibility study for the observatory ended with a proposal for a series of six radio telescopes of the steerable paraboloid variety, as follows: (i) a 600-foot telescope, the largest completely steerable instrument at the observatory; (ii) a telescope of 250- to 300-foot aperture; (iii) a 140-foot telescope of the highest attainable precision; (iv) two telescopes of the "standard" 60-foot or 84-foot size, both to be devoted to observational research programs; and (v) a relatively small (28 feet in diameter) telescope to be devoted primarily to pattern measurements and to the testing of receivers or other components under development at the observatory. It was also agreed that arrays and similar antenna devices would be installed at the observatory. However, these devices are less costly than steerable paraboloids, and it seemed best to treat them as expendable equipment that would be designed and built to meet the needs of particular research programs.

Early in the study it was recognized that radio astronomers require telescopes of high resolution, in order to be able to distinguish between two sources close together in the sky, and of high gain, to assist in the detection of the very weak celestial signals. Hence, a premium was placed on telescopes of large aperture. From purely structural considerations, the consensus of engineers consulted on the matter was that a paraboloid several thousand feet in diameter could be mounted to be fully steerable. But the cost would be very great. Accordingly, the steering committee decided that a structural design study should be undertaken for construction of a paraboloid of the more modest size of 600 feet. The work

was undertaken by Jacob Feld (*9*). Feld was asked to consider a paraboloid surface true to within 1 inch over the entire 600-foot aperture, and true to within ⅝ inch over the inner 300 feet of the aperture, as minimum goals, and a tolerance of ¼ inch over the entire surface as the desired goal. This reflector was to be mounted in a manner such that it could be pointed anywhere in the sky with an accuracy of 7 seconds of arc, and the maximum permissible angular rate of motion was to be at least 30° per minute. The Feld study, which was completed in July 1955, showed that it was technically feasible to build a steerable parabolic telescope. But Feld also found that the extreme tolerances imposed difficult structural problems, and he concluded that the most practical telescope design would probably be one that would incorporate various types of servo devices to keep the components of the telescope structure in the proper shape and adjustment.

By the summer of 1956 it became clear that the Navy would probably build a large radio telescope at Sugar Grove that might be available on a limited basis for astronomical research. Accordingly, plans for constructing fully steerable paraboloids in the 300-foot and 600-foot size range have been virtually abandoned for the observatory. However, certain astronomical problems require telescopes with very large equivalent apertures, and thought has been given to the possibility of installing very large antennas that would offer the large aperture at the expense of sky coverage or steerability.

The 140-foot telescope was proposed as a general-purpose research instrument. The exact size of this instrument has no significance. The 50-foot telescope at the Naval Research Laboratory has a reflector that is sufficiently true to permit work at radio wavelengths as short as 1 centimeter. The precision instrument for the National Radio Astronomy Observatory was to be about three times as large and to be of such quality as to permit work at wavelengths at least as short as 3 centimeters.

The specifications for the instrument have gone through several revisions, each more specific than the former and intended to make the telescope more useful for a variety of research purposes. The 140-foot paraboloid will have a focal length of 60 feet and, hence, a focal-length/diameter (f/d) ratio of 0.43. For all positions and in winds up to 16 miles per hour, the surface is to be true to ¼ inch. The surface will be of aluminum plate, ¼ inch thick, and composed of 72 panels; the individual panels are to be true to $\frac{1}{16}$ inch. These panels are to be mounted on adjustable shoes. Hence, for one position of the telescope and in the absence of strong winds or thermal effects, the user should be able, with great patience, to adjust the entire surface to about $\frac{1}{16}$ inch. To measure or survey a surface as large as the 140-foot paraboloid with this degree of precision is a problem of some difficulty.

The supports that will hold the radio-frequency horns and other electronic equipment at the focus of the paraboloid are to accommodate a load of 1000 pounds in a manner such that gravity deflections will not exceed ⅛ inch as the telescope scans the sky.

The paraboloid will be supported on an equatorial mount that will permit approximately the same sky coverage that is available with the Palomar 200-inch optical instrument. Because the total moving mass above the polar axis will exceed 2000 pounds, for this axis an "oil-pad" or hydrostatic bearing system is specified. At the north end of the polar shaft, a segment of a 22-foot-diameter sphere will rest on the equivalent of three pads. At the south end of the shaft, a cylinder 5 feet in diameter will be held by four pads that may be adjusted somewhat like the jaws of a four-jawed chuck.

This combination of bearings offers a simple means of aligning the polar shaft parallel to the axis of the earth. The drive and control system is to have an over-all precision of 10 seconds of arc, for good environmental conditions and slow rates of motion. In addition to automatic tracking rates, to compensate for the diurnal rotation of the earth and for the slow motions of the sun, moon, and planets relative to the stars, the telescope will be capable of scanning areas of the sky at rates as high as 8° per minute and with a pattern similar to the scan of the picture on a television tube. The telescope will also be capable of faster rates, up to 50° per minute, which in some future experiments may be controlled in order to keep the telescope pointed at a fast-moving object, such as an artificial satellite. The requirements for close

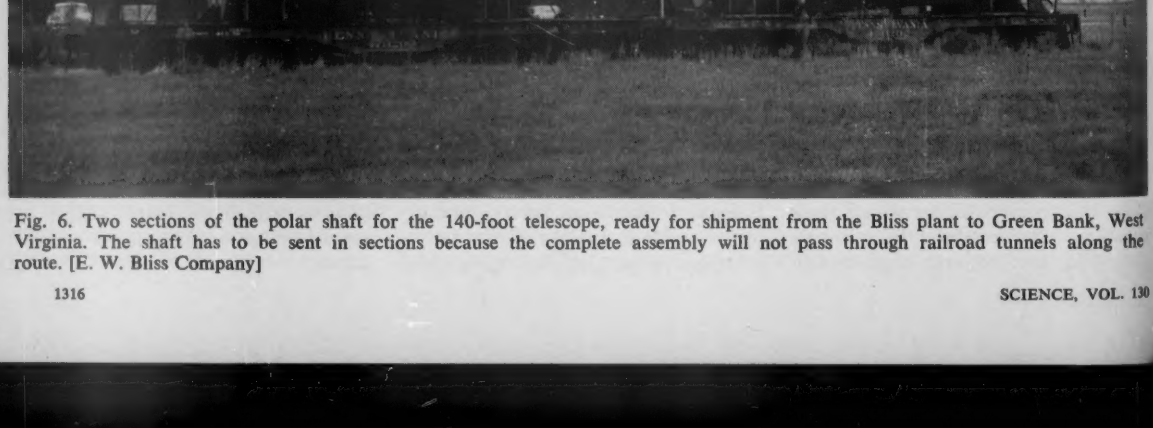

Fig. 6. Two sections of the polar shaft for the 140-foot telescope, ready for shipment from the Bliss plant to Green Bank, West Virginia. The shaft has to be sent in sections because the complete assembly will not pass through railroad tunnels along the route. [E. W. Bliss Company]

surface tolerances and great positional precision have placed a premium on rigidity of structure of the telescope.

The basic design of the telescope is the work of N. L. Ashton. An *ad hoc* advisory group consisting of T. C. Kavanagh (chairman), P. P. Bijlaard, J. G. Bolton, N. A. Christensen, A. M. Freudenthal, F. T. Haddock, M. B. Karelitz, D. P. Lindorff, E. F. McClain, E. J. Poitras, B. H. Rule, J. O. Silvey, and H. E. Tatel reviewed and assisted with the work. The Franklin Institute prepared the preliminary designs for the polar shaft bearings, and T. W. Brown developed a design for the drive and control system. The Canton division of the E. W. Bliss Company has the prime contract for construction of the telescope (Fig. 4). Darin & Armstrong, Inc., of Detroit, holds the subcontract for the field work at Green Bank. The Electric Boat Division of General Dynamics Corporation holds the subcontract for the drive and control system.

The foundation for the telescope, which will also serve as a control building to house the necessary auxiliary apparatus for the research scientists, is nearing completion at Green Bank (Fig. 5). Meanwhile, the first major component of the telescope, the polar shaft, was shipped from the Bliss plant on 29 August (Fig. 6). Because of the mammoth size of the instrument, final machining and assembly must be completed in the field.

In order that astronomical observations could be started at the National Radio Astronomy Observatory prior to the completion of the 140-foot telescope, and in recognition of the expressed need for access to a telescope of intermediate size by scientists at several institutions, a decision was made to purchase an 85-foot telescope from the Blaw-Knox Company. This instrument (Fig. 7) is on an equatorial mount, the basic design for which was suggested by M. A. Tuve and his colleagues at the Department of Terrestrial Magnetism, Carnegie Institution of Washington. The late Howard E. Tatel was one of the principal contributors to this design, and the National Radio Astronomy Observatory telescope has been named in his memory. Analysis of the mount reveals that it is, essentially, a series of nearly equilateral triangles: there are three concrete bases in the ground, two on the north side and one at the south; the polar shaft is the axis of a right-circular cone, its apex coinciding with the south end of the polar shaft and its base forming the truss for the polar drive gear, the sides and base being built up of triangular elements; and the heavy frame from the north end of the polar shaft to the ends of the declination shaft forms an important triangular configuration. These are examples of the triangular systems to be found in the telescope structure. The reflector is a paraboloid with an f/d ratio of 0.43, the same as that of the 140-foot telescope. This coincidence is desirable because a feed designed to operate with one reflector will also match the other. The reflector surface is made up of panels covered with aluminum sheet. The tolerances are such that the telescope may be used effectively at wavelengths as short as 3 centimeters. The drive and control system provides an accuracy of about 2 minutes of arc; the power components for this system are located in a shielded metal house beneath the telescope.

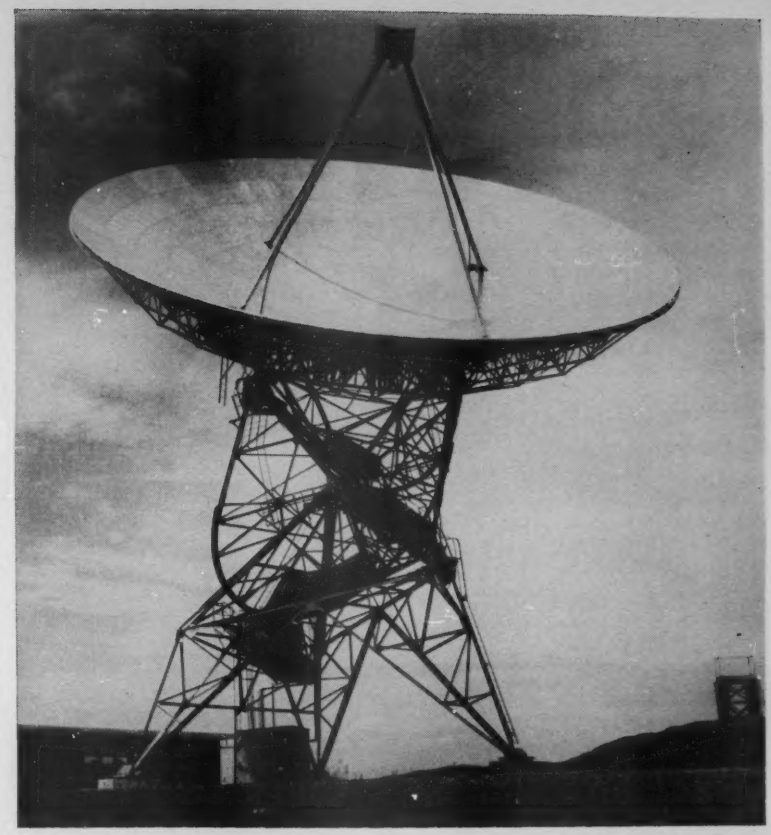

Fig. 7. The Howard E. Tatel 85-foot telescope. The control building is to the north. Some electronic components are mounted in the cylindrical container behind the horn feed at the focus. When the telescope is turned far to the east, an elevator provides access to the equipment at the focal point.

Electronic components that must be near the pickup feed are located in a weatherproof container supported behind the focus of the paraboloid. Other electronic components are located in metal boxes or sheds mounted behind the reflector near the declination bearings. The receiver indicators, data storage and processing equipment, and related apparatus are located in the control building, which is on the north side of the telescope.

A dual feed, operating at 3.75- and 21-centimeter wavelengths, was obtained from Jasik Laboratories. At the start of observational work with the telescope, early in 1959, it was found that a 3.75-centimeter receiver, procured from Ewen-Knight Corporation, and a 21-centimeter receiver, procured from Airborne Instruments Laboratory, could be operated simultaneously, without noticeable cross interference. Subsequently, a 75-centimeter feed and receiver, both designed and built by the National Radio Astronomy Observatory research equipment development de-

partment, have been added, and simultaneous observations at three wavelengths are now routine procedure.

Four other instruments at Green Bank are worthy of note. Reber's original telescope was requisitioned by the government during World War II. In 1955 it was located, completely dismantled, at the Boulder laboratories of the National Bureau of Standards. Because of the historical significance of the telescope, arrangements were made through the National Science Foundation for the transfer of the telescope to the National Radio Astronomy Observatory. The telescope is now being completely refurbished and rebuilt under Reber's personal supervision. The telescope will be mounted in the altazimuth form, as it was at the Bureau of Standards, rather than in the simple meridian form, as it was built by Reber in Wheaton, Illinois, more than 25 years ago. This telescope has a parabolic reflector some 30 feet in diameter and, therefore, will be valuable for experimental purposes, as well as for its historical interest.

A precision 12-foot parabolic spinning reflector with an f/d ratio the same as that of the 85- and 140-foot telescopes was found at a British firm. This reflector has been mounted on an old radar turret that provides 360° of azimuth motion, but only some limited motion in altitude. The 12-foot reflector will be used primarily for test purposes, particularly for pattern measurements in developing feeds and supports.

The feasibility study pointed out that the observatory would have a responsibility for establishing standards of measurements for radar astronomy. Because a horn is more susceptible to theoretical calculations than any other type of antenna, J. W. Findlay is constructing a large horn as part of the observatory's standardization program. The horn will be 120 feet long, with a 13- by 17-foot aperture; appropriately, it has been called the "little big horn." The horn will lie in a fixed position, selected so that the bright radio source, Cas A, will transit once each day.

An interferometer, consisting of two 38- by 38- by 50-foot corner reflectors situated on a 2000-foot east-west baseline, has been in operation for about a year. The interferometer is designed for use at low frequencies to record such phenomena as the sudden emissions from Jupiter.

The receivers for the radio telescopes will always be subject to improvement and modification, to take advantage of improved electronic components and techniques, and to meet the particular requirements of the individual research programs. For these reasons, the receivers and related electronic components are generally treated as items in the annual operating budget, rather than as a part of the capital equipment. The basic observational data—receiver output, telescope position, and time—are available in digital form to permit storage and processing by electronic computers. The receiver output is also normally recorded in strip form to permit immediate visual inspection by the research scientists.

Summary

The existence of the National Radio Astronomy Observatory and the researches already accomplished there are the result of the foresight and wisdom of United States scientists, the National Science Board, and the Congress, who joined forces to make possible this new national asset. Continued effort will be needed to insure that the observatory will always have the finest possible research instruments and that the site will be a haven of radio quiet. Visiting scientists in some instances may wish to bring equipment with them for studying special problems. Within its means, the observatory will provide supporting facilities, including receivers and other electronic devices, computers, laboratories and shops, and housing. Scientists interested in more details concerning arrangements for visitors should direct their inquiries to the National Radio Astronomy Observatory, P. O. Box 2, Green Bank, West Virginia.

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7. Associated Universities, Inc., is a nonprofit corporation chartered by the Board of Regents of the State of New York to acquire, plan, construct, and operate laboratories and other facilities, either under contract with the government of the United States or its agencies or otherwise, for research, development, and education in the physical, biological, and social sciences, including all aspects of the field of nuclear energy and its engineering and other applications, and to educate and train technical, research, and student personnel. The National Radio Astronomy Observatory is operated by Associated Universities, Inc., under contract with the National Science Foundation. The work reported in this article is supported by the National Science Foundation.
8. The committee commented that radio astronomers in a number of countries have indicated their desire to use for this purpose one frequency band at each of the following approximate positions (not necessarily in harmonic relation):

Frequency (Mcy/sec)	*Bandwidth (Mcy/sec)*
40	± 0.75
80	± 1.0
160	± 2.0
640	± 2.5
2560	± 5.0
5120	±10.0
10240	±10.0

9. J. Feld, *Ann. N.Y. Acad. Sci.* **70**, 153 (1957).

Sulfhydryl-Disulfide Interchange

This biological chain reaction explains aspects of protein denaturation, blood clotting, and mitosis.

Elwood V. Jensen

Recently it has become evident that a variety of phenomena involving proteins and peptides possess certain rather unusual features consistent with the assumption that existing disulfide bonds have been disrupted and new disulfide bonds have formed. Unlike the previously known cases of disulfide modification in proteins by reduction of these bonds to sulfhydryl groups followed by reoxidation of the latter to new disulfide linkages, the more subtle disulfide rearrangements here described take place in the absence of added reducing and oxidizing agents and appear to be chain-type reactions initiated in most cases by very small amounts of sulfhydryl compounds. Under appropriate conditions, the initiating sulfhydryl reacts with a disulfide group to form a new disulfide linkage, at the same time generating a new sulfhydryl group capable of reiterating the process (Fig. 1). Thus, a single sulfhydryl initiator can bring about the reaction of a large number of disulfide groups, and the occurrence of such processes, often under rather mild conditions, can exert far-reaching effects.

This article summarizes the reported examples of such sulfhydryl-disulfide interchange phenomena. Although most of these observations are concerned with in vitro transformations of proteins and peptides, it now appears that similar reactions are involved in certain physiological processes as well. It is hoped that the concept of a sulfhydryl-disulfide chain reaction may prove of value in elucidating the mechanisms of still other biological phenomena.

Protein Reactions

Most observations of sulfhydryl-disulfide interchange reactions have been concerned with phenomena accompanying protein denaturation, chiefly those of aggregation. The first indication that protein sulfhydryl groups play a role in the aggregation of denatured protein came from observations of the remarkable influence of the single sulfhydryl group of bovine plasma albumin on the nature of the clot or coagulum formed when solutions of this protein are heated (*1*). Clots formed by the thermal denaturation of ordinary bovine plasma albumin at neutral *p*H are opaque, friable, and synerizing, whereas those formed from albumin which has had its sulfhydryl group destroyed or blocked by treatment with an appropriate "sulfhydryl reagent" are transparent, firm, and nonsynerizing. Moreover, in the absence of the sulfhydryl group, solid gels are formed in solutions of much lower albumin concentration than when the sulfhydryl group is present. On the basis of existing concepts of gel structure (*2*), it was concluded that in the coagulum formed from sulfhydryl-containing albumin, the denatured protein chains lie in close side-by-side association and that the albumin sulfhydryl group must in some way bring about this type of aggregation (*1*).

The manner in which a sulfhydryl group is able to promote cross linking of protein molecules became apparent during subsequent experiments on the denaturation of proteins by urea (*3*). The previously known property of proteins such as plasma albumin, fibrinogen, γ-globulin, and egg albumin to form clear firm gels when exposed to concentrated urea (*4*) was shown to depend on the presence of small amounts of protein sulfhydryl groups. Gelation in urea or in guanidine hydrochloride is favored by increased *p*H, inhibited by oxygen, eliminated by blockage of protein sulfhydryl groups, and restored to sulfhydryl-free protein by the addition of trace amounts either of sulfhydryl-containing proteins or of simple mercaptans. Since the observed phenomena appear to involve a stoichiometry quite different from that usually encountered in protein reactions, it was proposed that, under the conditions of protein denaturation, the sulfhydryl group initiates a chain reaction with disulfide groups in the manner illustrated in Fig. 1, leading to a regular three-dimensional gel network in the case of urea denaturation (and to side-by-side association of protein molecules in the case of thermal denaturation where no urea molecules are present to hold the protein units apart).

Subsequent measurements (*5*) of viscosity changes in more dilute bovine plasma albumin solutions clearly demonstrated that, in addition to the large immediate increase in viscosity following exposure of the protein to concentrated urea, there is a further gradual sulfhydryl-dependent viscosity rise which is influenced by the same factors as is the gelation in more concentrated albumin solutions, and which thus reflects the disulfide interchange reaction. Similarly, in the case of thermal denaturation, the results of viscosity and sedimentation measurements on dilute albumin solutions, as well as the effect of traces of mercaptans on the thermal coagulation of iodoacetamide-treated albumin, furnish strong support for the concept that lateral association by sulfhydryl-initiated disulfide interchange takes place when albumin solutions are heated (*6*).

These considerations of a chain-type sulfhydryl-disulfide interchange reaction operating during conditions of protein denaturation have been confirmed and extended by a number of investigators. As part of an extensive study of the effect of urea denaturation on the viscosity and optical rotation of protein solutions, Kauzmann and his collaborators (*7*) have shown that, with both ovalbumin and bovine plasma albumin, an exchange reaction between sulfhydryl and disulfide groups is an important cause of aggregation during denaturation, especially at *p*H values above neutrality. Subsequent investigations of solubility changes during the course of urea denaturation of bovine plasma albumin permitted Kauzmann and Douglas (*8*) to distinguish between intramolecular disulfide exchange, which diminishes protein solubility only slightly, and intermolecular disulfide exchange leading to aggregation and a larger decrease in solubility. From the

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ability of reducing agents to decrease the light scattering of solutions of albumin which had been denatured by heat, shaking, or exposure to ethanol or urea, Halwer (*9*) concluded that the denatured protein is cross linked, at least partially, by intermolecular disulfide bonds, this cross linking being most pronounced in the case of the alcohol-treated protein.

From the effect of *p*H and of sulfhydryl reagents on the molecular weights of proteins in 7*M* urea, McKenzie, Smith, and Wake (*10*) concluded that, with bovine plasma albumin, the only cause of aggregation is sulfhydryl-disulfide interchange, which occurs under alkaline but not under acid conditions. With ovalbumin, aggregation appears to take place both by disulfide exchange and by hydrogen bonding, the latter being somewhat more important. Kolthoff and his coworkers (*11*) have studied viscosity changes of dilute bovine plasma albumin solutions after treatment with guanidine hydrochloride, and, in agreement with previously mentioned findings with urea, they have observed a gradual prolonged increase in viscosity, resulting from protein aggregation through sulfhydryl-disulfide interchange. After prolonged exposure of bovine plasma albumin to guanidine hydrochloride, the same authors observed a decrease in the reactivity of the protein sulfhydryl group toward silver or mercuric ions, which they attribute to the production, by sulfhydryl-disulfide interchange, of a sulfhydryl group less accessible to silver or mercury than the original one. Toward ferricyanide, the reactivity relationship is reversed; Kolthoff and Anastasi (*12*) have shown that the original sulfhydryl group in native bovine plasma albumin is not oxidizable by ferricyanide, but that exposure to concentrated urea or guanidine hydrochloride produces a new sulfhydryl group which, after removal of the denaturing agent, can be oxidized by ferricyanide to form a protein dimer.

A number of observations confirm the occurrence of disulfide interchange during thermal denaturation of proteins. The effect of oxidizing and reducing agents on the viscosity and turbidity of heated β-lactoglobulin solutions led Zittle and DellaMonica (*13*) to conclude that the protein sulfhydryl groups promote lateral association of peptide chains, with resulting opacity, although the effect is less pronounced than in the previously mentioned case of bovine plasma albumin (*1*, *6*). From the influence of sulfhydryl reagents on the sedimentation behavior of thermally denatured bovine plasma albumin and on its solubility in 83-percent acetic acid, Steinrauf and Dandliker (*14*) have shown that during the first 30 seconds at 100°C and *p*H 5.6, intramolecular rearrangement of hydrogen bonds takes place, after which a rapid intermolecular disulfide interchange commences, leading to polymerization. Somewhat similar conclusions were reached by Warner and Levy (*15*) working at the lower temperature of 65.7°C. Kinetic investigations, involving sedimentation studies of the intermediate products formed in this mild thermal denaturation of bovine plasma albumin in the presence and absence of sulfhydryl reagents, indicate that the initial reaction is an intramolecular sulfhydryl-disulfide interchange and that aggregation takes place subsequently, in part by an exchange mechanism of an intermolecular type.

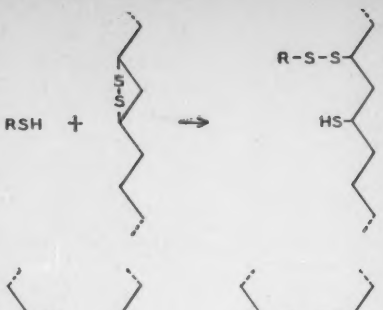

Fig. 1. Sulfhydryl-disulfide interchange in proteins.

Apparently, precipitation of a protein with alcohol is an especially favorable condition for disulfide interchange. In addition to the previously mentioned experiments with ovalbumin (*9*), Straessle (*16*) has reported that treatment of human plasma mercaptalbumin with cold aqueous ethanol of more than 60 percent alcohol content by volume can cause partial conversion of the protein to a dimer, a reaction which does not occur with iodoacetamide-treated albumin under similar conditions. This sulfhydryl-initiated cross-linking reaction provides an explanation for the earlier observation of Cohn, Hughes, and Weare (*17*) that aggregation of protein takes place during the methanol extraction of lipids from albumin. Recently, Rouser (*18*) has reported that nonprotein sulfhydryl compounds in plasma exert a marked influence on the alcohol precipitation of the protein. On the addition of ethanol, plasma from normal individuals gives a coarse granular precipitate, whereas plasma low in cysteine, obtained from chronic lymphatic leukemia patients, as well as solutions of commercial human plasma albumin, give a fine, difficult-to-filter precipitate which is slowly transformed to the coarse granular type upon addition of small amounts of cysteine.

The sulfhydryl-initiated transformation of intramolecular disulfide bonds to intermolecular linkages with accompanying gelation has been clearly demonstrated by Benesch and Benesch (*19*), who used a model protein, thiolated gelatin. This substance is prepared by treatment of gelatin, which itself contains no sulfhydryl or disulfide groups, with N-acetylhomocysteine thiolactone. Oxidation of the thiolated protein with ferricyanide in dilute solution gives a protein with intramolecular disulfide linkages, as indicated by the lack of change in its viscosity and sedimentation characteristics on oxidation. Treatment of a solution of the oxidized protein with a trace of mercaptoethylamine causes an immediate transformation into a firm, heat-stable gel similar to that produced by oxidation of the thiolated gelatin in concentrated solution where intermolecular disulfide bonds are formed directly.

In a practical application of sulfhydryl-disulfide interchange, Arnold (*20*) has cross linked a monomolecular layer of fibrinogen to afford a semipermeable protein membrane for use in model cell membrane studies. A thin layer of fibrinogen in saline is floated carefully on an aqueous surface, and the addition of cysteine to the water effects two-dimensional cross linking of the protein to form a stable film.

A somewhat different protein phenomenon considered to involve sulfhydryl-disulfide interchange is the long-range elasticity of wool. When a wool fiber is stretched in water by an amount greater than about 30 percent, irreversible structural alterations take place which have been postulated to result from the rupture of disulfide linkages (*21*). Since the sulfhydryl content of wool was found to be unaltered by the stretching process, Burley (*22*) has sug-

gested that stretching brings a sulfhydryl group into contact with a disulfide group whereupon interchange takes place to form a new disulfide linkage in a manner which relieves the mechanical strain. In support of this exchange mechanism, Burley observed that wool fibers with their sulfhydryl groups blocked by previous reaction with iodoacetamide or N-ethylmaleimide stretch at a much slower rate and to a lesser extent than do untreated, sulfhydryl-containing fibers under the same conditions. Moreover, untreated fibers which stretch readily in water are resistant to stretching in 0.1*N* hydrochloric acid, an environment unfavorable for the sulfhydryl-disulfide reaction.

Klotz and his coworkers (*23*) have studied the interaction between the sulfhydryl group of bovine plasma albumin and the disulfide-containing dyestuff 2, 2'-(2-hydroxy-6-sulfonaphthyl-1-azo)-diphenyl disulfide. In this case, only the first stage of the sulfhydryl-disulfide chain reaction appears to take place. To explain the stoichiometry observed, the authors propose a novel type of long-range intramolecular sulfhydryl-disulfide interchange in the albumin molecule, which involves electron transport by way of the hydration lattice of the protein.

Two examples of reversible protein aggregation in the absence of denaturing agents have been ascribed to sulfhydryl-disulfide interchange. These are the association of soluble feather keratin, which takes place as the protein concentration is increased (*24*), and the dimerization of bovine plasma albumin, which occurs when the *p*H is lowered to 3.4 or below (*25*). These phenomena differ from those previously described not only in that they are manifest in the absence of conditions which disrupt the protein structure but also in that the aggregation appears to be freely reversible by such relatively mild manipulations as dilution or raising of the *p*H to neutrality. Moreover, in the case of bovine plasma albumin, the aggregation is observed in a *p*H region where sulfhydryl-initiated disulfide interchange ordinarily does not occur. Although these examples may represent rather special cases of disulfide exchange, it would seem advisable to consider the alternative possibility that some other type of sulfhydryl-dependent aggregation may be involved.

It is now established that sulfhydryl groups can contribute to the association of protein units in ways other than through disulfide bonds. In addition to the well-known dimerization of albumin by reaction of sulfhydryl groups with divalent mercury (*26*), it appears that the sulfhydryl group itself can interact with some other protein group or groups to form a stable but reversible linkage. Participation of sulfhydryl in a thiazoline structure, first proposed by Linderstrøm-Lang and Jacobsen (*27*), has been demonstrated by Calvin (*28*) to exist under certain conditions in the peptide glutathione. Madsen and Cori (*29*) have observed a reversible, sulfhydryl-dependent aggregation of the enzyme phosphorylase. Deutsch and Morton (*30*) have reported an association of human serum macroglobulin units which appears to involve sulfur-containing groups, and Lorand (*31*) has described a somewhat similar aggregation for the fibrin stabilizing factor of blood plasma. Finally, the existence of a stable but reversible intramolecular "sulfhydryl bond" has been proposed (*32*) to account for several rather unusual properties of bovine plasma albumin. Thus, the multiple possibilities for the role of sulfhydryl groups in linking protein units together should be borne in mind when one is considering sulfhydryl-dependent aggregation phenomena in protein systems.

Peptide Reactions

In the foregoing examples, protein disulfide groups appear to participate in interchange reactions under conditions of denaturation. No doubt most disulfide groups in native proteins are either hindered or otherwise unreactive (*33*), so that some disruption of protein structure is necessary to make them available for reaction. Without this restriction, disulfide exchange reactions could take place indiscriminately in physiological systems, and chaos would ensue in the living cell. In the case of simpler peptides and amino acids, however, the disulfide groups are readily available, and interchange reactions often take place with amazing ease, even with peptides which contain no sulfhydryl groups as initiators.

This fact was first reported by Sanger (*34*) after observations that an acid hydrolyzate of insulin may contain many more cystine peptides than can be accounted for by any unique structure for the protein. In a subsequent study, Ryle and Sanger (*35*) demonstrated that disulfide interchange in peptide solutions at 37°C can take place either in neutral or in alkaline medium or else in strongly acid medium (7 to 12*N* HCl) with little or no exchange observed in moderately acid solutions. The former process is accelerated by an increase in *p*H or by the addition of mercaptans and inhibited by sulfhydryl-blocking reagents, whereas disulfide interchange in strongly acid solution is inhibited by added mercaptans. Cognizant of these facts, Sanger and his associates (*36*) were able to devise conditions for the hydrolysis of insulin so as to avoid disulfide interchange and the resulting artifacts among the peptides produced.

Additional examples of disulfide exchange reactions both in acidic and in alkaline media have been described by Schöberl and Gräfje (*37*), who also found that illumination with ultraviolet light promotes disulfide interchange. Although the latter observation suggests the possibility of disulfide interchange by a free radical mechanism, because of the *p*H dependence of the photochemically induced exchange, the authors consider it probable that the illumination in some way promotes the formation of mercaptide ions rather than initiating a free radical process.

Ressler (*38*) has observed that on standing at room temperature in sodium bicarbonate solution the cystine-containing peptide hormone oxytocin undergoes loss of biological activity accompanied by aggregation and decreased solubility. This behavior is ascribed to a disulfide interchange reaction which produces intermolecular disulfide linkages; the latter can be cleaved, and biological activity can be partially restored, by treatment of the inactivated hormone with cysteine, glutathione, or hydrogen sulfide. Since the inactivation takes place under the mild alkaline conditions ordinarily used for the preparation of dinitrophenyl derivatives of proteins and peptides, the need for caution is noted in the interpretation of results involving dinitrophenyl derivatives of disulfide-containing peptides.

Reaction Mechanisms

The sulfhydryl-initiated disulfide interchange illustrated in Fig. 1 undoubtedly is analogous to the intermediate step in the reduction of simple disulfides by mercaptans, a reaction which has been studied extensively (*39*) and which is known to proceed by nucleophilic attack of a mercaptide anion

(RS^-) on the disulfide bond. Unless they are strongly influenced by other factors, such as changes in electrostatic repulsive forces between the charged protein molecules (*1*), disulfide interchange reactions of this type would be expected to proceed at a more rapid rate as the *p*H, and thus the mercaptide ion concentration, is increased. In the protein experiments discussed above in which comparisons have been made, an increase in *p*H has been found to enhance phenomena ascribed to the disulfide interchange reaction.

In the case of peptides which contain no sulfhydryl groups, the disulfide interchange reaction in neutral or alkaline solution appears to proceed by a similar mechanism, the initiating sulfhydryl group being produced by the hydrolysis of a disulfide bond (*35*). In strongly acid medium, on the other hand, disulfide exchange takes place by a different mechanism, demonstrated recently by Benesch and Benesch (*40*) to involve electrophilic attack of a sulfenium cation (RS^+) on the disulfide bond. Under the action of strong hydrochloric acid, the following reactions occur:

$$R\text{-}S\text{-}S\text{-}R + HCl \rightleftarrows RSCl + RSH \quad (1)$$

$$RS^{\oplus}Cl^{\ominus} + R'\text{-}S\text{-}S\text{-}R' \rightleftarrows R\text{-}S\text{-}S\text{-}R' + R'SCl \quad (2)$$

The known reaction of mercaptans with sulfenyl chlorides (*41*) appears to be partially reversible, so that small amounts of sulfenyl chloride are formed from the disulfide (reaction 1). The sulfenyl chloride then reacts with a disulfide, in a manner also described by Moore and Porter (*42*), to form the mixed disulfide and to regenerate a new sulfenyl chloride which carries on the process (reaction 2). Marked enhancement of disulfide exchange is observed upon the addition of small amounts of sulfenyl chlorides or sulfenic acids (RSOH), which in strong acid can give rise to sulfenium ions, as well as of hydrogen peroxide, which reacts with disulfides to produce sulfenium ions. That the acid-catalyzed exchange is inhibited by the addition of mercaptans is readily understandable, since the presence of these substances reverses reaction 1 and thus depletes the amount of sulfenyl chloride, the concentration of which is already rate-limiting.

Physiological Processes

The foregoing examples of disulfide interchange reactions are in vitro processes which take place when a protein or peptide is subjected to chemical or physical manipulation. Whether similar interchange reactions take place in vivo is a question of considerable interest, and there are now strong indications that sulfhydryl-initiated disulfide interchange may play a role in certain important physiological processes.

One such phenomenon is the clotting of blood fibrinogen (*43*). It is well established by the work of Robbins (*44*) and of Lorand (*45*) that the fibrin clot formed from the action of thrombin on purified fibrinogen (fibrin-*s*) is different from the physiological clot obtained from the coagulation of blood or of recalcinated plasma (fibrin-*i*). Fibrin-*s* is soluble in *5M* urea or in weak acid or alkali, whereas fibrin-*i* is insoluble in these reagents and also possesses much greater mechanical strength. The formation of the insoluble type of fibrin requires the presence both of calcium ions and of a nondialyzable, heat-labile substance present in blood plasma, known variously as Laki-Lorand (L-L) factor, fibrin-stabilizing factor (FSF), or urea-insolubility factor. The properties of fibrin-*i* indicate that this clot possesses stable cross linkages not present in fibrin-*s*, whereas the fact that fibrin-*i* dissolves readily in a mixture of urea and thioglycolic acid (*46*) suggests that these additional cross linkages are disulfide bonds.

The observation that small amounts of sulfhydryl-blocking reagents prevent the formation of urea-insoluble fibrin clots led Loewy and Edsall (*47*) to propose that fibrin-*i* is cross-linked by intermolecular disulfide bonds produced through a sulfhydryl-initiated interchange of the disulfide groups of fibrin-*s*. With the subsequent isolation of the fibrin stabilizing factor in purified form (*31, 48–50*), and the demonstration that this substance contains from one (*49*) to two (*50*) equivalents of titratable sulfhydryl per 100,000 grams of protein, sulfhydryl which is essential for FSF function, this factor would appear to possess the necessary qualifications to be an initiator of disulfide interchange.

During the clotting process, sulfhydryl groups are produced whose reactivity appears to be considerably increased over that of the original FSF sulfhydryl (*49*). Inactivation of FSF by pretreatment with silver ions requires ten times the silver concentration necessary to prevent fibrin-*i* formation when the silver is present during the clotting process, whereas iodoacetamide will inhibit fibrin-*i* formation but will not inactivate FSF on pretreatment. These observations of Loewy's are reminiscent of Kolthoff's (*11, 12*) studies on aggregated plasma albumin after guanidine hydrochloride treatment, and they are consistent with the involvement of a sulfhydryl-disulfide interchange mechanism in the formation of fibrin-*i*.

Whether the sulfhydryl groups of FSF are the only such groups which can initiate the conversion of fibrin-*s* to fibrin-*i* is not certain. Earlier findings that simple mercaptans (*47*) or plasma albumin (*51*) could promote this transformation have been attributed by Lorand and Jacobsen (*52*) to a regeneration of inactivated FSF tenaciously bound to the protein employed, since, with their fibrinogen preparations, neither cysteine nor plasma albumin showed any FSF activity. However, Loewy (*49*) has prepared fibrinogen which by immunological criteria appears to be free of bound FSF, and preliminary experiments with this material indicate that simple mercaptans do show FSF activity when present in rather high concentration. Thus, further study is required before agreement can be reached as to the specificity of the FSF as the reaction initiator. In any case, the concept that FSF, augmented in some way by calcium ions, effects cross linking of fibrin molecules through a sulfhydryl-disulfide interchange reaction provides a reasonable explanation for the formation of the physiological fibrin-*i* clot.

A second biological phenomenon which may involve sulfhydryl-disulfide interchange is that of cell division. It has long been known (*53*) that during mitosis the acid-soluble sulfhydryl (glutathione) content of the sea urchin egg exhibits a cyclical variation; it decreases after fertilization, reaches a minimum at about the time of spindle formation, and returns to its original level prior to cleavage. After observations that the protein sulfhydryl content of the sea-urchin egg likewise varies, but with an inverse relationship to the variation of the glutathione level, and also that the isolated mitotic apparatus is soluble in sodium thioglycolate, Mazia (*54*) proposed that disulfide bonds are important structural features of the mitotic apparatus and that the formation of this entity may involve the polymerization of small protein molecules through a glutathione-initiated disulfide interchange reaction. The construction of the mitotic apparatus is considered to involve both gelation of protein through intermolecular disul-

fide bond formation and orientation of the gel structure through secondary bond production; the orientation but not the gelation process is prevented by the mitotic inhibitor, colchicine (*55*). The participation of sulfhydryl groups in mitosis is further indicated by the reversible blockage of the mitotic cycle of sea-urchin eggs by the addition of small amounts of mercaptoethanol (*56*), whereas the ability of mercaptoethanol to induce twin formation, when present during a particular stage of the cleavage cycle of *Dendraster* eggs, suggests that the simple mercaptan competes with protein sulfhydryl groups in the formation of disulfide bonds involved in interblastomere linkages (*57*). Although many details of the complex physiological process of mitosis remain to be elucidated, the intriguing suggestion that sulfhydryl-disulfide interchange plays an important role affords a promising approach for further investigation.

Eldjarn and Pihl (*58*) have reported that cystamine and cysteamine administered to a mouse rapidly become incorporated into the blood proteins, apparently by a sulfhydryl-disulfide exchange. This finding suggests that disulfide interchange reactions with body constituents may be intimately concerned with the protective action of these sulfur compounds against ionizing radiation.

Whether sulfhydryl-disulfide interchange plays a role in other biological phenomena remains to be investigated, although certain additional suggestions along these lines have been put forward. In view of the previously mentioned inactivation and reactivation of oxytocin, presumably by a disulfide exchange mechanism, Ressler (*38*) has suggested the possibility that disulfide-containing peptide hormones, such as oxytocin and vasopressin, may exist physiologically in an inactive form, with activation taking place at appropriate sites under the influence of sulfhydryl compounds such as glutathione. After observations of what appears to be a long-range intramolecular sulfhydryl-disulfide interchange in bovine plasma albumin mediated through the bound water lattice, Klotz (*23*) pointed out that such a mechanism could furnish a means of electron transport in oxidation-reduction reactions involving sulfhydryl enzymes, especially in systems which appear to transfer energy over a distance. Other processes in which the possibility of disulfide interchange should be considered include the production of keratin and the formation of such physiological protein gels as the mitachondrial framework or the lens of the eye. Disulfide linkages are relatively abundant in most protein molecules, whereas sulfhydryl and disulfide are potentially among the most reactive of the protein functional groupings, although, as was pointed out above, their reactivity ordinarily is more or less restricted by the characteristic structure of the protein molecule. It is not unreasonable to consider that the physiological initiation and control of many important processes in living organisms may depend on factors which establish and regulate conditions under which interaction between protein sulfhydryl and disulfide groups can take place.

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Science in the News

Soviet Scientific Information System Held To Be Much Like Ours in Structure and Operation

The scientists, engineers, and administrators who have to cope with the problems of distributing to their colleagues the published work of researchers in their own and other countries often cite the Soviet Union as the nation where this problem is best handled. One national center, well-staffed and solidly financed, does the job there, they say, of translating, abstracting, and distributing published scientific reports and papers both from within the country and from without. It has been suggested that we might profitably imitate this approach.

But reports from recently returned visitors to the Soviet Union and Poland indicate that the "approach" is changing, and that if we were to imitate it as it is today, we would, in effect, be imitating ourselves. There is not just one center, but a complex system, these reports indicate, and the general trend in the system is toward greater decentralization, with more emphasis placed on regional sub-units than on national centers. The methods of distributing reports on domestic and foreign research are far from perfect, the visitors report, and there is frequent criticism, both in scientific journals and during national and international meetings. Mechanical means of speeding up distribution are, in many cases, not even in the blueprint stage.

These points and others, which experts in the United States had guessed, were confirmed during the 25th conference of the International Federation for Documentation held in Warsaw in September. Burton W. Adkinson, a U.S. delegate to the conference and head of the Office of Scientific Information Service of the National Science Foundation, took the occasion to question the Soviet delegates on matters concerning the changing scientific information system in their country. He based his questions on information that had been gathered by his Washington staff and on material supplied by delegates from some of the satellite countries.

State Committee in Control

The informal conversations between Adkinson and the Soviet representatives brought out the fact that the All-Union Institute of Scientific and Technical Information, which is generally regarded in this country as the one central organization for distribution of published scientific information, is just one of the units of a larger structure and not the most important or influential. The larger unit, the State Committee for Science and Technology, both directs the All-Union Institute and maintains its own information office, which according to reports has the more significant role. This office, the Department of Scientific and Technical Information, under the direction of Oleg A. Mikhailov, has responsibility for all of the scientific and technical information centers for industry. This responsibility, when viewed in relation to other political and economic developments in the Soviet Union, explains the new and growing influence of Mikhailov's department.

Briefly, these developments are as follows. A reorganization, begun in May 1957, of Soviet industry transferred control of the industries from the various ministries to regional groups. As a consequence, the scientific and technical information system which had served the industries had to be decentralized. The change in organizational structure did not affect the technical information services alone, because much basic research has always been conducted in industrial laboratories. These decentralized industries, scattered widely throughout the U.S.S.R., needed some means of keeping their scientists and engineers abreast of new developments. The coordination of these information centers was given to Mikhailov's department.

Because of this responsibility for all of the regional industrial centers, and because of the scientific work done in them, the department has outstripped the All-Union Institute as a center for processing scientific information. There are, Adkinson reports, many indications of the changing roles of the State Committee vis-à-vis the All-Union Institute. Most translation of foreign journals, for example, is no longer done at the institute. Only one of the scientific review series is published by the institute. Research in methods of mechanized information-processing is being carried on largely in universities, not at the institute. Recently the institute has been given the job of publishing a number of new abstract journals dealing with the fields of transportation, public health, mining, and construction. These facts are viewed by observers as evidence that applied science and technology are being given the greater emphasis, and that Mikhailov's department is benefiting.

Similarity to U.S. Pattern

The end effect of the changes now taking place in the Soviet Union, Adkinson and other observers suggest, is that the Russian researcher learns about the work of others in his field in much the same way that his American counterpart does. Each industry has a center from which he can receive abstracts of relevant papers. This large center supports smaller centers in the individual factory. These regional units offer abstracting, translation, and extracting services as well as literature searching and bibliographic service, and all provide regular library service. New journals are started as they are needed, and they are staffed by men directly involved in the field of science concerned. Academy or institute authorization is almost always required before publication of a new journal is undertaken.

According to very recent reports, the "give-away" period, during which Soviet scientists and engineers could receive translations and abstracts for a nominal fee or free of charge, is now coming to an end. Soviet scientific-information practices are becoming "very Western," one recent visitor reports. One major difference does remain. The system of professional journals, abstracting services, and society publications used in this country developed from the needs of the sciences and technologies concerned. It is part of the pattern of private enterprise. The Soviet system is state directed and closely tied to national planning.

Visitors to the Soviet Union report

that if one is interested in gaining information from Soviet officials, the best approach is to ask, not how things work, but, rather, whether this is the way things work. If the questioner can show an official that he is fairly well informed, he has a better chance of getting an answer. If the reports are correct, American scientists attempting, for example, to arrange an exchange of scientific publications might well take advantage of the new system for handling scientific information in the U.S.S.R.

Cooper Union's Second Century

The 100th anniversary of The Cooper Union for the Advancement of Science and Art in New York was celebrated on 2 November. Delegates of about 300 educational institutions and societies marched in the academic procession that opened the centennial observance.

In the course of sessions on "New Values in Science, Art, and Society," Laurence M. Gould, geologist and president of Carleton College, spoke on "Education and Society," and Sir Kenneth Clark, art critic and historian and chairman of the Arts Council of Great Britain, discussed "Art and Society." Two recipients of Nobel Prizes shared an afternoon session devoted to "Science and Society." They were Sir John Cockcroft, physicist member of the United Kingdom Atomic Energy Authority and master designate of the new Churchill College of Cambridge University, and Harold C. Urey, professor-at-large of chemistry at the University of California, La Jolla.

Cooper Union is the oldest tuition-free, private educational institution in the United States. It consists of a day and evening school of engineering, a day and evening school of art and architecture, an adult education division, a museum for the arts of decoration, and a library.

The Union's undergraduate schools of engineering and art are open to all residents of the United States, regardless of race, religion, or sex, who qualify in the competition for admission. Talent and intellectual ability are the basic requirements for entrance. Of the 1597 applicants tested in 1958, 396 were accepted; this brought the current enrollment to 1300.

Since its founding, Cooper Union has offered free public lectures and programs. Its evening forums attract audiences of about 1000 people, three times a week.

History

Cooper Union was founded by Peter Cooper (1791–1883), builder of "Tom Thumb," the first American locomotive; sponsor, with Cyrus Field, of the laying of the Atlantic cable; and ironmaster who fabricated the iron beam which made possible construction of the skyscraper. He was perhaps the first wealthy man to maintain, and support by action, the tenet that wealth is a trust to be used for the benefit of the public. In starting the school, his purpose was:

"To provide regular courses of instruction at night free to all who shall attend the same on the application of science to the useful occupations of life, and on such other branches of knowledge as will tend to improve and elevate the working classes of the City of New York.

"To provide and maintain a school for the instruction of respectable females in the arts of design and to afford to respectable females instruction in such other art or trade as will tend to furnish them suitable employment."

When evening classes began on 7 November 1859, 2000 men and women, each armed with a certificate of "good moral character," then the only requirement for entrance, presented themselves for instruction in mathematics, chemistry, mechanical philosophy, architectural drawing, free-hand drawing, and vocal music. Historian Allan Nevins says Cooper Union was the "first great experiment in adult education in this country . . . It was also the first great trade school for women in America."

The contrast between the Cooper Union of 1859 and that of today is spectacular. In 1859 the faculty numbered 20 teachers, as against 160 now. The first annual budget was about $35,000; today's budget is about $1,750,000. A century ago, when a college education was for the few, Cooper Union offered a modest education for the many. Today, with more than 3 million Americans in colleges, Cooper Union's role has changed to that of giving, insofar as it is financially able to do so, the best possible professional education without cost to the selected few who prove themselves best able to use it.

In connection with its centennial observance, which will continue through

Three scientists who participated in Cooper Union's 100th anniversary convocation: (left to right) Laurence M. Gould, geologist and president of Carleton College; Harold Urey, professor-at-large of chemistry at the University of California, La Jolla; and Sir John Cockcroft, physicist member of the United Kingdom Atomic Energy Authority.

the academic year of 1959–60, the Cooper Union has started a development program, of which the first step is the construction of a new building for the School of Engineering. The structure is now well under way and is expected to be occupied during the coming year. Its completion will pave the way for renovation of the present buildings and for expansion of the Art School's curricula to full degree-granting status.

Jodrell Bank Radio Telescope Controlled by Computers

The towering structural splendor of Manchester University's radio telescope at Jodrell Bank, England, which in its first months of operation earned an international reputation in satellite tracking, has to some extent obscured a remarkable electronic engineering achievement—the precise mechanical control of the 2000-ton rotating aerial. To appreciate the extent of this achievement, it is necessary to be aware of the really great size of the Jodrell Bank equipment. The parabolic reflecting bowl, a "dish" of steel plates 250 feet in diameter and weighing nearly 800 tons, can be tilted to any angle to control the elevation of shoot of the aerial. It can even be turned upside down to change the aerial.

The paraboloid is pivoted between two steel towers, each rising 180 feet from a system of deep-trussed girders not unlike railway bridges. All this array of steel is supported on bogies that travel on a circular railway track 352 feet in diameter; these allow the structure to be steered in azimuth. The 2000 tons of hardware can be rotated and the bowl can be rocked to aim the aerial with an accuracy in each coordinate of better than 12 minutes of arc. That figure is the required accuracy, but in fact, in reasonable weather an accuracy of 3 or 4 minutes of arc can be achieved.

Change in Design

Initially it had been planned to make the reflector of wire mesh stretched over a system of tangential supporting members; this would have given a deviation from the true paraboloid of several inches. At short wavelengths—in the region of 1 meter—an error of this magnitude would have resulted in considerable loss of signal, so it was decided to change the design and to form the bowl of individually shaped and welded steel plates. This, of course, made a big difference in the weight and windage of the bowl and necessitated a major redesign of some parts of the structure.

The electronic problem was that of providing a driving system sufficiently powerful to move the telescope in azimuth and elevation under all but the most severe wind conditions and a method of controlling this driving source so that the telescope could automatically follow any point in space, irrespective of the rotation of the earth and its movement round the sun. Two identical closed-loop servomechanisms are used; each must control four variable-speed direct-current motors of 50 horsepower each, operating within a speed range of 10 to 1000 revolutions

Control desk of the Jodrell Bank radio telescope.

per minute, by Ward Leonard voltage control; an additional speed range of from 1000 to 1500 revolutions per minute can be obtained by weakening the motor field.

The coordinated movement in azimuth (about a vertical axis) and elevation (about a horizontal axis) is controlled by signals from an analog computer. The small signals from the computer require amplification at ratios up to 30 million to 1, achieved in the main by direct-coupled amplifiers.

Obviously the design and development of the control machinery at Jodrell Bank was a major task. Requirements were set by the Manchester University staff, under A. C. B. Lovell, and the resulting instrumentation, involving new techniques in electronic and mechanical engineering, was the responsibility of Herman Lindars, managing director of the firm that carried out the work, Dunford and Elliott (Sheffield) Ltd. The Brush Electrical Engineering Company Ltd. was responsible for the manufacture of the machines, motor-control gear, and reduction gear that provide the physical motive power for the telescope.

Basic Facilities

The remote control of the telescope gives it these basic facilities:

1) It can be locked in any given azimuth and elevation.

2) It is capable of continuous motion in azimuth with fixed elevation; or in elevation with fixed azimuth, at any required rate.

3) By coordinating azimuth, elevation, and time, the telescope can be given sidereal motion for following any particular star.

4) It can be set on a predetermined program of search in which it can be left to sweep methodically a given area of the sky.

The computer controlling the electronic-mechanical "engines" which give movement to the telescope is a complex one. While the telescope is capable of movement in only two basic coordinates, to follow a star it is necessary to set up the control in its fixed coordinates, right ascension and declination, and the computer must be capable of translating these into the physical voltage changes that control the driving motors. In order for the telescope to scan across or along the Milky Way, another set of coordinates, galactic latitude and longitude must be employed. Again, it is sometimes necessary to scan in azimuth and elevation and at the same time to read off the positions either in right ascension and declination or in galactic latitude and longitude—or both. The computer, therefore, must be capable of solving, instantaneously and continuously, fundamental equations of spherical trigonometry.

The computer consists of an electrical analog in which magslip resolvers solve the equations by giving output signals proportional to the sine and cosine of the angle through which their rotors are turned. Excitation of the stator windings is given through feedback amplifiers deriving the feedback voltage from auxiliary stator windings. High-gain, two-stage resistance-capacitance-coupled amplifiers obviate nonlinearity in output due to electrical losses and unwanted flux.

No Single Equation

There is no single equation that can be used for control over all parts of the sky. This difficulty is overcome by using 14 different equations in the computer. Cams on the shafts of the resolvers automatically switch in the appropriate equations according to the position in the sky of the target. Seven of these equations are used for calculating azimuth and elevation from hour angle and declination (and vice versa), and another seven serve for calculating latitude and longitude from right ascension and declination.

An additional elevation resolver, set by a calibrated potentiometer on the control desk, is used to correct for parallax error arising when a body near the earth, such as the moon, is observed. The equations for distant targets are computed on the assumption that the viewer is at the center of the earth, while, of course, the telescope is mounted at the earth's periphery. Parallax correction is therefore needed when the viewer is working, as it were, "close up."

Similarity to Television Scanning

When the telescope is required to scan a given area, a "target arc" is selected. As each lateral sweep is completed a pulse can be provided to depress or elevate the arc of scan by a given amount, so that a scanning raster is built up; this is faintly similar to the technique of television scanning, except that the direction of sweep is reversed for each successive line. The raster can be arranged in vertical or horizontal scan and control is fully automatic. The coordinates of the scan can be coupled to a time control that will shift the complete raster in accordance with sidereal time.

In all movements of the telescope, indicator dials show at the control desk the position in which the aerial is firing. Dials indicate degrees and minutes of arc and hours, minutes, and seconds of time. Other dials show sidereal time, universal time, and the repeated-back positions in azimuth and elevation of the telescope itself. This information is given with an accuracy of better than 1 minute of arc.

Sidereal time is obtained by a synchronous motor which is controlled by a regenerative oscillator driving through a power amplifier. The speed of this motor is compared every 30 seconds with a pendulum-driven master clock and the motor is driven at a rate very slightly faster than the required sidereal time would call for. If at the time of the 30-second check the motor-driven clock is in advance of the master clock, a capacitor is switched across the input to V.1, reducing the oscillator frequency and the speed of the sidereal motor to bring the clocks back into coincidence.

J. STUBBS WALKER
Sunday Graphic, London, England

Neurology Federation Opens Office: Neurochemistry Commission Formed

The World Federation of Neurology, which was founded only about 2 years ago, now has a permanent secretariat at 59, rue Philippe Williot, Berchem–Antwerp, Belgium, and a full-time medical executive officer, Charles M. Poser, who is on leave from the University of Kansas. The WFN serves as an information center for world neurology. Its present plans include encouragement of international collaborative studies of neurologic and sensory disorders and establishment of a clearinghouse of information to promote exchange professorships, lectures, and consultancies.

The organization also expects to serve as a focal point for the development of scientific registers and repositories of pathologic specimens and scientific literature. Still other projects include the publication of a world directory of neurologists and neurologic scientists, preparation of a dictionary of neurologic drugs and poisons, compilation of lists of neurologic journals throughout the

world, and the maintenance of an up-to-date calendar of national and international neurologic meetings.

The federation is composed of national neurological societies in about 40 countries, which together have approximately 10,000 members. Ludo van Bogaert of the Institut Bunge, Antwerp, is president of the new organization. The other officers are as follows: vice presidents, Macdonald Critchley (Great Britain) and August Tournay (France); secretary-treasurer general, Pearce Bailey (United States); and chairman of the Committee on the Constitution and Bylaws, G. Schaltenbrand (Germany).

Problem Commissions Formed

The WFN has organized several problem commissions to review and evaluate the status of research and research opportunities in specialized areas. These commissions will also study the efficacy of international pooling of scientific talent and facilities for a more effective approach to a given research problem. Ten commissions have already been founded, in the following areas: neuropathology, neurochemistry, comparative neuroanatomy, history of neurology, tropical neurology, child neurology, and neuroanesthesia.

The Neurochemistry Commission is the most recently formed. It met for the first time 29-30 September in Antwerp. Those present were Derek Richter, John Cumings, and Everson Pearse (England); Armand Lowenthal (Belgium); Lars Svennerholm and Gunnar Brante (Sweden); Hans Bauer (Germany); George Edgar (Netherlands); Saul Korey, Jordi Folch-Pi, and Wallace Tourtelotte (U.S.); Judah Quastel (Canada); and Ludo van Bogaert and Charles M. Poser (ex-officio).

Biological Sciences Curriculum Study Formed

The Biological Sciences Curriculum Study, which has headquarters at the University of Colorado, was recently organized by the American Institute of Biological Sciences, with support from the National Science Foundation, to make a broad study of education in the biological sciences at all levels of instruction from elementary grades through the university. In the initial phases of the work, attention will be focused on the secondary school, perhaps the pivotal area in American education today.

The major objectives of the study group, which is made up essentially of an autonomous body of biologists and educators, is to design a coordinated and modern life-sciences curriculum; to recommend a sequence of courses in other subjects of study; and to explore the possibility of designing special courses for exceptional students at all levels. Projects are already being carried out by committees that have been formed in the following areas: course content, innovations in laboratory instruction, teacher preparation, publications, and the gifted student.

Consultants for the curriculum study are engaged in assembling case-histories of a representative group of teachers who are generally recognized to be exceptionally effective, to determine what factors made them successful and to discover any common denominator. The consultants are also preparing a digest of published information on biological science education. In addition, a number of units of course material in biology, teachers' manuals, and laboratory exercises that were prepared during team-coordinated summer writing conferences will be tested and revised for publication. As an aid to in-service teachers, to students, and to laymen interested in biological science, a series of review pamphlets will be issued. A newsletter on the activities of the Biological Sciences Curriculum Study may be obtained by writing to The Director, BSCS, University of Colorado, Boulder.

Science Equipment Purchase Guide

School officials, teachers, and consultants in elementary and secondary schools will find valuable information and direction in the *Purchase Guide for Programs in Science, Mathematics, and Modern Foreign Languages*, recently published by the Council of Chief State School Officers. The 336-page volume contains descriptions of approximately 1000 items of equipment used for instruction in elementary science, mathematics, general science, modern foreign languages, biology, chemistry, and physics. Each description includes an item number, the accepted name of the equipment, a short statement about its possible uses in instruction, and brief specifications as to function, which assist the purchaser in making a selection from among various commercial offerings. A "coding" is also provided for each item to suggest the areas of instruction and the type of course—basic, standard, or advanced—in which the item will be found useful.

Lists of equipment for each of the subjects covered are included in the book to assist purchasers in reviewing their present stocks of equipment. The book also contains "guidelines," short essays on special problems of instruction, and a select list of books and films for each area.

Edgar Fuller, executive secretary of the council, assisted by a seven-member advisory committee, was in charge of the project. The Educational Facilities Laboratories, Inc., provided a major share of the funds.

The *Purchase Guide* may be obtained for $3.95 from Ginn and Company, Statler Building, Boston 17, Mass.

Plant Material Exchange Program Reopened between U.S. and U.S.S.R.

A program for the exchange of plant research materials between the U.S. and the U.S.S.R. has been reactivated this year after 15 years in which there was no official exchange, according to the U.S. Department of Agriculture. The program was revived at the instigation of plant breeders in both countries, some of whom have participated in exchange visits. International exchange of plant materials was begun in 1898 by USDA's Plant Introduction Section, but exchange with Soviet Russia was discontinued about 1944.

Cooperative exchange of new and indigenous varieties of plants between the United States and the U.S.S.R. has proved to be highly beneficial to both countries because of similarities in climate, agricultural interests, and crop problems. Before 1944, U.S. plant breeders received several important types of grasses and alfalfa from Russia; from U.S. contributions under the program, Russia now raises 10 million acres of sunflowers of American origin—a major source of vegetable oil in that country.

Since last March, 577 shipments of forage (grass, legume), oilseed, and small-grain and cereal-crop seeds have been exchanged. Future exchanges this year will include tobacco stock and varieties of fruit, according to H. L. Hyland, supervisor of the exchange program in the United States and head of the Plant Introduction Section of

USDA's Agricultural Research Service.

Requests for foreign plant materials by U.S. research agencies and corresponding requests for U.S. seed from abroad are cleared at USDA's Plant Industry Station, Beltsville, Md. In the U.S.S.R., all exchange of seed is through the All-Union Institute of Plant Industry, Leningrad.

Bibliography Service for Biological Photography

The Medical Group of the Royal Photographic Society of Great Britain has announced the establishment of a bibliography service for papers on photographic techniques with applications in the medical and biological sciences. Such papers are published in a very large number of journals, and it is therefore difficult to use the existing literature for solving both theoretical and practical problems.

The bibliography consists of punch cards, each of which carries an abstract of an original article. Almost 400 new cards are added annually. The present total of such classified abstracts is more than 2000. The cards are grouped under "Kinematography," "Photography," "Administration," and "Microscopy" before they are subdivided further. The librarian is therefore able to cite references of papers which have a bearing on any problem concerned with photography in medicine or biology.

The service is extended, free of charge, to all bona fide inquirers. Detailed requests for references to the literature should be addressed to: J. A. Fairfax-Fozzard, School of Anatomy, University, Cambridge, Great Britain.

Grants, Fellowships, and Awards

Atomic energy. The Atomic Energy Commission is accepting applications for 237 graduate fellowships for 1960–61 in nuclear science and engineering, health physics, and industrial hygiene. All 237 are for U.S. citizens. Information about the three programs may be obtained from the Fellowship Office, University Relations Division, Oak Ridge Institute of Nuclear Studies, P.O. Box 117, Oak Ridge, Tenn. A description of each program follows.

1) Nuclear science and engineering: 150 fellowships are available for first, intermediate, and final years of graduate school. The prerequisites are a bachelor's degree in engineering or physical science, and mathematics through differential equations. The fellowships are for 12 months of study at 49 participating universities. The basic stipend is $1800 for the first year, $2000 for the intermediate year, and $2200 for the final year, with additional allowances for dependents. The fellowships are awarded on a 1-year basis, but renewals are available. The deadline for filing aplications is *1 January 1960*.

2) Health physics: 75 fellowships, five leading to the Ph.D. degree and 70 for 1 year of graduate study, are being offered in this program. The five fellowships for advanced training in health physics, leading to a doctorate in disciplines closely related to health protection, will be available each year. Applicants must be actively engaged in health-physics work and have a minimum of 2 years of productive experience in the field. Fellows may choose their graduate school, subject to the concurrence of the ORINS Fellowship Board. The stipend is $4000 per year plus $400 for each dependent. Up to $2500 per year is allowed to the graduate school selected, to cover tuition and extraordinary costs. The deadline for applications is *1 February 1960*.

To be eligible for any of the other 70 fellowships, the applicant must have a bachelor degree in biology, chemistry, engineering, or physics, with adequate preparation in related fields, and must have completed mathematics through calculus. Participants must be under age 35. These fellowships provide for an academic year of formal work at an assigned university, followed by three summer months of training at an AEC installation. Participating institutions are Harvard and Vanderbilt and the universities of California, Kansas, Michigan, Rochester, and Washington. Commission installations cooperating in the program are Argonne, Brookhaven, and Oak Ridge national laboratories, Lawrence Radiation Laboratory, National Reactor Testing Station, and Hanford Atomic Products Operation. A limited number of extensions are available for additional work to complete the master's degree. The stipend is $2500 for 12 months, with an additional allowance for dependents. The deadline for applications is *1 February 1960*.

3) Industrial hygiene: 12 fellowships are available in this program, which leads to the master's degree. An applicant must be under 35 years of age and must have a bachelor's degree, with a major in physics, chemistry, or engineering. Additional academic training or industrial experience is desirable. The fellowship is for one academic year, and the stipend is $2500. There are additional allowances for dependents and for industrial experience. The participating institutions are Harvard and the universities of Cincinnati, Michigan, and Pittsburgh. The deadline for applications is *1 March 1960*.

Biological sciences. Applications are invited for the third annual Turtox Scholarship established by General Biological Supply House, Inc. The $5000 award is open to any U.S. citizen who is currently, or who has been, enrolled in a graduate school and who is, or is contemplating, continuing study for the doctorate degree in botany, zoology, or biology. The award will be based upon evidence bearing upon the promise of the applicant as a prospective teacher and research scholar. Application blanks may be obtained from the chairman of the award committee, Professor Frank A. Brown, Jr., Department of Biological Sciences, Northwestern University, Evanston, Ill. Completed forms must be returned by *1 February 1960*.

General Atomic. The Oak Ridge Institute of Nuclear Studies has issued a 24-page illustrated brochure describing the research-participation opportunities for college and university faculty members that exist at Oak Ridge. This program provides faculty members with appointments of from 3 months to a year on research staffs of Oak Ridge laboratories. The laboratories in which research opportunities exist touch virtually every field of scientific endeavor. Copies of the new brochure and application blanks are available from the ORINS University Relations Division, P.O. Box 117, Oak Ridge, Tenn. Applications for summer appointments (of 3 months' minimum duration) should be submitted to ORINS, with letters of recommendation, by *15 December*.

Physics. The Organization of American States and the National Atomic Energy Commission of Argentina have announced cosponsorship of an 8-week Summer Institute of Physics to be held at San Carlos de Bariloche, Argentina, beginning about 18 January 1960. The major purpose of the institute is to give intensive graduate-level training in solid-state physics, nuclear physics, and electronics to university physics professors and instructors throughout the hemisphere.

Approximately 15 fellowships, which will provide funds for international

travel, housing, subsistence, and other expenses incident to the course, will be awarded by the Organization of American States in accordance with recommendations of a special selection committee. Applicants must possess at least the equivalent of a B.S. degree in physics and have an excellent command of the Spanish language. Preference will be given to candidates engaged in university teaching, training, or research.

Instruction will be given by the staff of the permanent Institute of Physics of San Carlos de Bariloche and by visiting professors from leading universities throughout the hemisphere. Director of the institute is Jorge Sabato, who is also director of the Division of Metallurgy of the Argentine National Atomic Energy Commission and a professor of physics at the University of Buenos Aires.

Interested individuals may send a resume of their education and experience to Dr. Jesse D. Perkinson, Division of Science Development, Pan American Union, Washington, D.C. Resumes must be received on or before *4 December*.

News Briefs

The National Science Foundation has announced the award of grants totaling about $9.2 million to 33 colleges and universities to support Academic Year Institutes for science and mathematics teachers. This will be the fifth year of this program, which was organized to help teachers increase their knowledge in their subject areas through a year of advanced study on a full-time basis. Approximately 1600 experienced teachers will be enrolled in the institutes in the 1960–61 academic year; of these the great majority will be secondary-school teachers. In 4 years, 3400 science and mathematics teachers have participated in the institutes.

* * *

A scientific conference on disposal of radioactive wastes resulting from the peaceful uses of atomic energy will be held at the Oceanographic Museum in Monaco from 16 to 21 November. The conference will be cosponsored by the International Atomic Energy Agency and the United Nations Educational, Scientific, and Cultural Organization, with the active cooperation of the Food and Agriculture Organization. The meeting is intended to familiarize geologists, oceanographers, and fisheries experts with problems involved in the disposal of nuclear wastes and to enable them to discuss specific questions with atomic-energy specialists.

* * *

The Third Venezuelan Geological Congress will take place in Caracas, Venezuela, 22–29 November. This is the first such meeting to be held since 1938. The agenda establishes commissions in various areas, including general geology, stratigraphy, applied geology, petrogeny, and tectonism and sedimentation. The meeting is being promoted by the Venezuelan Society of Geologists; it is sponsored by the Ministry of Mines and Hydrocarbons, Division of Geology. For information write to Mr. Anibal R. Martinez, Jersey Production Research Co., 1133 N. Lewis Ave., Tulsa 10, Okla.

* * *

A group of students from the United Arab Republic is arriving in Canada to undertake scientific studies in Canadian universities. The students, who are all at the postgraduate level, will study physics, chemistry, electrical and civil engineering, metallurgy, soil science, soil chemistry, and botany. All their expenses will be paid by the government of the U.A.R., which asked Canada's help in the education program shortly before the start of the current academic year.

* * *

The American Epilepsy Federation, a new lay epilepsy organization, was formed in Milwaukee on 13 September. The federation, composed of 23 affiliates in 11 states, represents an effort to unite all existing lay societies into a single cohesive unit. The federation's president is Mrs. Albert Grass of Quincy, Mass.

* * *

The proceedings of the Sixth Midwestern Conference on Fluid Mechanics and the Fourth Midwestern Conference on Solid Mechanics, meetings which were held jointly at the University of Texas, 9–11 September, are available at $12.50 per volume from the Engineering Institutes, Division of Extension, University of Texas, 18th and Red River Streets, Austin, Tex.

* * *

Sanitary Engineering Manpower has been issued by the U.S. Public Health Service. The data for the survey were gathered in cooperation with the National Science Foundation's scientific and engineering manpower unit. The 32-page pamphlet provides a collective picture of the age, education, professional experience, years of service, kind and type of employment, income, and related characteristics of approximately 4000 sanitary engineers, a group which represents almost two-thirds of the total estimated number of such engineers in the country. The report, PHS publication No. 703, may be obtained from the Government Printing Office, Washington 25, D.C.

* * *

The Council on Library Resources, Inc., has granted $72,965 to the Brookings Institution for a survey of federal departmental and agency library facilities. Luther H. Evans, former director general of UNESCO, will serve as senior counsultant for the project, which will be under the direction of Charles A. H. Thompson of Brookings. This survey will be the first major over-all appraisal of federal library facilities. Results of the study will be published early in 1961.

* * *

Arid Lands Research Newsletter, reporting current activities in all disciplines concerned with research on arid regions and with emphasis on western North America, will be published by the Committee on Desert and Arid Zones Research of the AAAS Southwestern and Rocky Mountain Division. News for publication and requests for copies of the *Newsletter* should be sent to the Editor, Richard B. Woodbury, Department of Anthropology, University of Arizona, Tucson.

* * *

The Society of Women Engineers will have its headquarters on the third floor of the United Engineering Building that is being built at United Nations Plaza in New York. It is hoped that the prestige gained by the society through its new headquarters in the Engineering Center will accelerate the development of wide-scale interest in engineering as an attractive profession for young women.

* * *

The indexing activities of the American Medical Association and the National Library of Medicine will be conducted in the future on a coordinated basis. Beginning with the issue for January 1960, the National Library of Medicine will publish monthly issues only of a new medical index to be called the *Index Medicus*. The American Medical Association will publish annual cumulations of the index, to be

known as the *Cumulated Index Medicus*. Subscriptions for the *Index Medicus* will be handled by the Superintendent of Documents, Government Printing Office, Washington 25, D.C., as is customary for all government publications; the *Cumulated Index Medicus* will be sold and distributed separately by the American Medical Association.

* * *

A new publication series has been founded, the *Occasional Papers of the C. C. Adams Center for Ecological Studies*. The first number will appear in late 1959 or early 1960. Those interested in being placed on the mailing list should write to Thane S. Robinson, director, C. C. Adams Center for Ecological Studies, Western Michigan University, Kalamazoo, Mich.

* * *

The Mellon Institute, Pittsburgh, Pa., has opened a major addition, the Bushy Run Laboratories located some 25 miles east of Pittsburgh. The new facilities consist of the Chemical Hygiene Building and the Radiation Research Building, the first two in a series of proposed special buildings, each devoted to a particular field of scientific investigation.

* * *

Wittenberg College, Springfield, Ohio, has announced that the name of the institution has been changed to Wittenberg University.

Scientists in the News

R. Hill, of the School of Biochemistry, University of Cambridge, England, will be a visiting professor during the winter term of 1960 in the department of chemistry, Oregon State College, Corvallis. He will lecture in biochemistry and will conduct a research project on biological oxidation.

The Christopher Columbus International Award for outstanding achievement in telecommunications was presented 12 October to **Brig. Gen. David Sarnoff**, chairman of the board of Radio Corporation of America, **E. W. Engstrom**, senior executive vice president, and **V. K. Zworykin**, honorary vice president of RCA.

Boston College has appointed **Robert L. Becker** to its department of physics as associate professor. He has been assistant professor at the University of Kentucky.

Recent honorary degrees include the following.

Harold Jefferson Coolidge, director, Pacific Science Board, National Academy of Sciences–National Research Council, from George Washington University.

William C. Steere, director of the New York Botanical Garden, from the University of Montreal.

Richard E. Shope, member of the Rockefeller Institute, **Karl F. Meyer**, veterinary medical research investigator, and **Hadleigh Marsh**, veterinary scientist and member of the Montana State College faculty, from the University of Pennsylvania.

Louis Schneider, formerly of Purdue University, has been appointed professor of sociology and head of the department of sociology, University of Illinois, Urbana. He will begin his duties on 15 March 1960. At present, he is visiting professor of sociology at Dartmouth College.

New appointments at the U.S. Naval Civil Engineering Laboratory, Port Hueneme, Calif., include the following:

Arthur B. Chilton, director of the Research and Development Division of the Navy's Bureau of Yards and Docks, has become director of the laboratory. He succeeds **Charles J. Merdinger.**

William B. Plum, head of the Thermal Branch of the U.S. Naval Radiological Defense Laboratory, has become head of the newly created Applied Science Department.

E. Vernon Potter, formerly with the Electronics Design Division of the Navy's Bureau of Ships, has become director of the Physics and Electronics Division.

Lorin J. Mullins, on leave of absence as associate professor of biophysics at Purdue University, has been appointed visiting professor of biophysics in psychiatric research at the University of Maryland School of Medicine.

Robert S. Davidow has been appointed as a research associate, and **John Oliver Millham**, as a senior chemist, to the staff of the research department of Philip Morris, Inc. The new appointees have been assigned to the Philip Morris Research Center in Richmond, Va. They had been, respectively, with the Armour Research Foundation and the U.S. Food and Drug Administration.

Van Olin Nicolai has been named associate physicist at Armour Research Foundation of Illinois Institute of Technology.

Franklin G. Liming, director of the Forest Research Center, Central States Forest Experiment Station, Columbia, Mo., has been appointed assistant to the director of the division of forest management research, U.S. Forest Service, Washington, D.C.

Stanley W. Nitzman has been appointed manager of the Atomic Energy Commission's Schenectady (N.Y.) Naval Reactors Operations Office. He succeeds **Jon B. Anderson**, who resigned last May to become deputy director of the New York State Office of Atomic Development.

Paul DeH. Hurd, associate professor of science education at Stanford University, is spending the 1959–60 academic year as educational consultant to the AIBS Biological Sciences Curriculum Study, located on the campus of the University of Colorado.

H. M. Powell, formerly research advisor in the biological division of Eli Lilly and Company, has been appointed research professor of pediatrics, Riley Hospital, Indiana University Medical Center, Indianapolis.

Rufus Oldenburger, School of Mechanical Engineering, Purdue University, has received the International Federation of Automatic Control award for meritorious service.

Bertha A. Klien has been appointed professor of ophthalmology in the department of surgery of the University of Chicago School of Medicine. She had been associate professor of ophthalmology at the university since 1955.

James W. McRae, vice president of the American Telephone and Telegraph Company and chairman of the Army Scientific Advisory Panel, has received the Army's Distinguished Civilian Service Medal for his contributions toward development of a series of small, tactical nuclear weapons.

Arnold J. Lehman, director of the division of pharmacology, U.S. Food and Drug Administration, Washington, D.C., was honored at the fall meeting of the American Society for Pharma-

cology and Experimental Therapeutics. During the ceremonies a plaque, on which the names of the winners of the Arnold J. Lehman Prize in pharmacology are engraved, was unveiled. The annual prize goes to a student at the School of Medicine, University of Miami, who shows great promise in pharmacology.

Augustus B. Kinzel, vice president for research of Union Carbide Corporation, was recently named recipient of the Industrial Research Institute Medal for 1960. The medal has been awarded annually since 1945 to honor outstanding accomplishment in industrial research. It will be presented next May at the annual meeting of the institute.

Gardiner L. Tucker has been appointed resident manager of the San Jose, California, research laboratory of the International Business Machines Corporation. Tucker, formerly manager of the IBM Research Planning Staff joined IBM in July 1952 as a research physicist at the Watson research laboratory in New York City.

Ernst Opik of Armaugh Observatory, Northern Ireland, has been reappointed visiting professor of physics at the University of Maryland for the academic year 1959–60. **Peter S. Farago** of Edinburgh University, Scotland, also has been appointed visiting professor for 1959–60.

C. J. Pings, formerly of Stanford University, is now associate professor of chemical engineering at the California Institute of Technology.

Maj. Gen. August Schomburg, Army deputy chief of ordnance, will succeed **Maj. Gen. John B. Medaris**, who will retire 31 January as head of the Army Ordnance Missile Command at Huntsville, Ala.

The following British scientists have received John Price Wetherill medals of the Franklin Institute, Philadelphia, Pa., for their development of gas-liquid (partition) chromatography:

A. J. P. Martin, director of research at Griffin and George Research and Development, Ltd., Wembley, Middlesex;

R. L. M. Synge, research biochemist at Rowett Research Institute, Bucksburn, Scotland;

A. T. James, research biochemist at the National Institute for Medical Research, London.

F. F. Nord, professor of organic chemistry and enzymology at Fordham University, was honored at a dinner on 17 October by the alumni, faculty, and administration of the university on the occasion of his 70th birthday. F. Lipmann of the Rockefeller Institute delivered the principal address and presented him with a collection of papers published in a special issue of the *Archives of Biochemistry and Biophysics*. R. Pelmont of the French Embassy presented him with the medal of the Société de Chimie Biologique.

John M. Wild will join General Dynamics Corporation's General Atomic Division as director of Project Orion. He will also become assistant director of the division's John Jay Hopkins Laboratory for Pure and Applied Science in San Diego, Calif. He had been director of engineering for A.R.O., Inc., which operates Arnold Engineering Development Center for the U.S. Air Force at Tullahoma, Tenn.

A new $150,000 fund, the Truman G. Schnabel Fund, "to aid worthy students of the Medical School," has been established at the University of Pennsylvania in memory of Cornelia Warren Hopeman, a former patient of **Truman G. Schnabel**, emeritus professor of medicine of the university.

Ernest F. Barker, professor emeritus of physics at the University of Michigan, has been appointed lecturer for the academic year 1959–60. He will teach two courses designed to prepare a selected group of high-school physics teachers to present a course in high-school physics which has been developed over the past 3 years by a physical science study committee working at the Massachusetts Institute of Technology.

Richard H. Boutelle, physicist at the Brookhaven National Laboratory, has been named chief health physicist for the Nuclear Division of the Martin Company, Baltimore, Md.

Franz Schrader, professor of zoology at Columbia University, has been appointed visiting professor of zoology at Duke University, Durham, N.C.

Jacob Rabinow, president of the Rabinow Engineering Company, Inc., Washington, D.C., has been awarded an Edward Longstreth Medal by the Franklin Institute, Philadelphia, Pa., on 21 October.

John Read, professor of chemistry at the University of St. Andrews, Scotland, has received the 1959 Dexter Award in the history of chemistry, administered by the American Chemical Society, at a meeting of the Chemical Society in London.

Kenneth A. Norton, chief of the Radio Propagation Engineering Division at the Boulder (Colo.) Laboratories, National Bureau of Standards, will receive the Harry Diamond Memorial Award during the convention of the Institute of Radio Engineers in New York in March 1960.

I. S. Ravdin has been elected vice president for medical affairs of the University of Pennsylvania. He will continue his surgical practice, and his duties as professor of surgery in the School of Medicine. **Jonathan E. Rhoads**, professor of surgery and former provost of the university, has been elected John Rhea Barton Professor of Surgery, chairman of the department of surgery of the School of Medicine, and director of the Harrison Department of Surgical Research, posts which Ravdin had held since 1945.

Joan B. Christie has joined the university relations division of the Oak Ridge Institute of Nuclear Studies as an assistant scientist. She is a member of the training staff for the ORINS "traveling teachers."

Recent Deaths

Sydney N. Baruch, New York, N.Y.; 74; electrical engineer and inventor; former chief research engineer for the General Arc Lighting Co.; 22 Sept.

George M. Eisenberg, Philadelphia, Pa.; 47; chief of the division of bacteriology and immunology at Philadelphia General Hospital; coauthor of *Anti-Microbial Therapy in Medical Practice*; 26 Oct.

Cherry L. Emerson, Atlanta, Ga.; 71; former vice president of Georgia Institute of Technology; 26 Oct.

Ralph C. Mize, Los Gatos, Calif.; 83; retired meteorologist, formerly in charge of U.S. Weather Bureau stations at Juneau (Alaska), Cleveland, and Buffalo; 8 Oct.

Louis J. Waldbauer, Albany, N.Y.; 63; chemist and supervisor of the analytical research and technical information section of the General Aniline and Film plant in Rensselaer, N.Y.; 20 Oct.

Book Reviews

The Study of Politics. The present state of American political science. Charles S. Hyneman. University of Illinois Press, Urbana, 1959. xi + 232 pp. $4.50.

Political scientists, according to Charles Hyneman, are "unhappy about the state of their discipline." We are unhappy for any one or all of four reasons which fill Hyneman himself with apprehension: (i) fear that we engage too much in activities which divert us from scholarly study and adversely affect the quality of the studies we make; (ii) fear that we have set ourselves too great a task in scholarly study: that we have committed ourselves to objectives of inquiry which in magnitude and diversity are too great to be encompassed in a discipline; (iii) doubt that our scholarly enterprise promises to achieve results worthy of a place in the total structure of learned literature; (iv) doubt that we have fitted our efforts adequately with the efforts of other disciplines that share with us the whole study of social relationships.

Heaven knows, political scientists are engaged in a multitude of activities ranging from exigetical writing on the "classics" to advising governments here and abroad on the technical aspects of a great variety of managerial problems. In between times and almost incidentally, they participate in teaching undergraduates in the liberal arts curriculum, and in training specialists in everything from public accounting and budgeting to recondite theories of power politics. Hyneman expresses a legitimate concern lest their preoccupation with extramural and extracurricular matters, with training rather than education, and with public affairs and applied research rather than the cultivation of basic learning and research, may dull the edges of their scholarly interests and competences. For scholarship, including teaching and basic research, is "the primary task of the political scientist." Participation in public affairs can no doubt enrich and enliven both his teaching and his scholarship, but sound scholarship will bring more to public affairs than participation in public affairs will contribute to scholarship. Moreover, although scholarly study "can be carried on effectively by political scientists who remain aloof from the public forum, . . . the reverse is not true." The "political scientist cannot take expertise as a political scientist to the public forum except as he carries with him the fruits of scholarship."

Hyneman is careful not to push the distinction between participation in public affairs and scholarship too far. They are not mutually exclusive fields of endeavor. There are enough reservations in his forebodings to acquit Hyneman of the fallacy of an excluded middle term. It is, after all, a matter of emphasis. Scholarship in political science which ignores the world of everyday public affairs can easily degenerate into arid scholasticism, just as an undue involvement in so-called "practical politics" can transform the scholar into a journalist or a ward boss. Hyneman, who obviously favors the scholar over the activist, would avoid these pitfalls by infusing scholarship with moderate doses of active statesmanship. But just how this is to be done, he does not say. Nor does he offer any substitute for the very substantial contributions to both scholarship and statesmanship of activists as varied as Aristotle, John of Salisbury, Machiavelli, Locke, J. S. Mill, Edmund Burke, Thomas Jefferson, and Woodrow Wilson, to mention but a few.

Although Hyneman avoids making the choice between scholarship and statesmanship an *either-or* proposition, he poses other equally difficult alternatives even for those political scientists who share his own preference for scholarship. As scholars, he says, political scientists are normally concerned with one or more of the following types of inquiry: (i) the "description of legal governments"; (ii) the "examination of ideas"; (iii) the "construction of a science"; (iv) the analysis of "normative doctrine and proposals for social action." In successive chapters he examines these types of inquiry at some length and, in doing so, seems to suggest that the true scholar must not only eschew participation in public affairs but, if he is to make any significant contribution, must specialize in one or another of these "fields." To encompass more than one such "field" is to attempt too much and, by doing so, to run the risk of being superficial and unscientific.

Hyneman finds the publications of American political scientists pretty discouraging. Although their major preoccupation for many generations has been with the "description of legal governments," Hyneman finds serious gaps even in the literature of this field. "Our literature," he says, "does not provide a full account of the organizational structure for deciding constitutional issues . . . [or] a full description of the processes of judicial decision and action. . . . We have made little exploration of the relationships of lower federal courts to constitutionality of legislation. . . . We have not, as a discipline, won any praise for comprehensive, accurate, illuminating accounts of court-made policy which stems out of language in state constitutions. . . . Finally, our writing about constitutional law and the judicial process does not provide thorough descriptions of the human environment that provides the setting for or conditions the process which is the central point of attention in this literature."

Nor have we done much better in the "examination of ideas," or in the "construction of a science." Concerning the first of these, Hyneman concludes, "as is the case with our efforts at description, our accomplishments in examination of ideas fall far short of our commitment." In this area we lag sadly and badly behind our European colleagues. Nor can it be said that, except for a few examples of what Hyneman calls "variable analysis," we have made any very substantial progress toward the "construction of a science" of politics. Since the controlled experiment is, for all practical purposes, unavailable to the political scientist, he is compelled to rely mainly on careful observation, description, classification, and analysis of political "entities." But, says Hyneman, "Descriptive studies that meet

stern requirements of scientific method are as yet too few to support much hope that the findings they report will ultimately add to other findings and so contribute to generalizations worthy of a place in scientific literature."

It is perhaps ironical that the major contributions of political scientists to our civilization have been in the fields of "normative doctrine and proposals for social action," fields which Hyneman would have them deemphasize if not avoid entirely. "Political scientists," according to the late Leonard White, "took a major responsibility for the reconstruction of municipal government. . . . They led the way in the reorganization of state governments. . . . They were influential in the drive for a short ballot and better election procedures. They were chiefly responsible for educating the American public to the necessity of a budget system. They began the long process of discussion that finally . . . reversed the historical direction of American foreign policy. . . . Suffice it to say that where good works are to be done on the body politic, there political scientists are to be found." These are no mean achievements, and they have been accomplished by men and women who were unafraid to mix scholarship with active statesmanship.

Hyneman has a good deal to say about how *scientific* political science can be without sacrificing a legitimate concern for political values. He calls for a more rigorous analysis of means and ends and for a more pragmatic use of political theory, and especially of the so-called "classics," in this analysis. Unless I misread what he has to say, Hyneman takes a dim view of those who, in their zeal for scientific method, would focus the attention of political scientists on such concepts as "power" and "influence," "behavior" or "decision making," to the exclusion of their more traditional concern with "legal government" and political ideas. "If," he asks, "the study of influence offers high hope of arriving at generalizations, why isn't the traditional study of political scientists right down the line? Legal governments are great systems of influence; they provide readily accessible demonstrations of power, which is influence backed up by compelling sanctions."

There is much in this volume that is confusing and even contradictory. Much of Hyneman's own terminology shows the same lack of careful definition for which he takes his colleagues to task. He appears to be impatient with those who indulge in detailed textual exegesis of political classics, although it is hard to see how the real meat of these great works can be extracted without such analysis. Time and again he uses *power* and *influence* as synonymous terms, although they refer to profoundly different aspects of political behavior. He does less than justice to the so-called "behavioralists" and seems to assume that somehow "legal governments," "ideas," and "normative doctrine and proposals for social action" can have meaning and significance apart from the political behavior of living men and women. He correctly criticizes political scientists for being fuzzy-minded generalists but pleads for greater and greater breadth in those specialized fields to which he would direct their efforts. And while taking political scientists to task for attempting too much, he calls upon them repeatedly to do more and more.

Nevertheless, Hyneman has done political scientists a notable service in holding up this mirror to their achievements and their shortcomings. This volume deserves a wide, careful, and critical reading by all those who profess what has long been described as the "queen of the sciences," the ancient and honorable science of politics.

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Complete Field Guide to American Wildlife. East, Central and North. Henry Hill Collins, Jr. Harper, New York, 1959. xix + 683 pp. Illus. $6.95.

The World of Living Things. Paul Griswold Howes. Duell, Sloan and Pearce, New York, 1959. xix + 232 pp. Illus. $4.50.

Curious Naturalists. Niko Tinbergen. Basic Books, New York, 1959. 280 pp. Illus. $5.

These three books are quite dissimilar, but they have in common a primary focus on the animal kingdom. The first is a field identification manual, the second is a series of reflective essays on natural history themes, while the third blends, in a highly intriguing fashion, a series of glimpses into the fascinating and bewilderingly diverse lives of various creatures with an informal account of the experiences and joys the author has had in the course of his studies.

Collins' book *Complete Field Guide to American Wildlife*, covers, in its 683 pages, all the species of mammals, birds, reptiles, amphibians, food and game fishes, shells, and principal marine invertebrates of North America east of the Rocky Mountains and north of Mexico. The use of the word *wildlife* is thus restricted to animal life aside from insects. Not only are about 1400 species of animals treated in some detail in the text, but 700 of them are shown in color and 800 in black-and-white. Over 2000 maps and other illustrations are included in this ambitious and seemingly well done manual, which is intended to be a "one-book-library" for use in the field. A rapid sampling of the contents gives me the impression that it will prove to be a reliable and handy guide.

Howes' book, *This World of Living Things*, is intended for reading, rather than for field use. While the creatures described are as varied as collembolans, the tropical forests of British Guiana, infusorians, and the human species, Howes tells us that these are not random sketches, but were carefully chosen from a great many that, at one time or another, occupied his attention. The 10 chapters and their documentation are uniformly good and hold the interest of the reader. The book is written in such a way that it introduces the nonnaturalist to various aspects of the world of living things and shows him, in simple and straightforward descriptions, what a wonderful and richly rewarding world it is. Howes has worked for many years in the field of popular education as writer and lecturer, and as curator of the Bruce Museum in Greenwich, Conn. The present book shows an experienced hand and an ever-alert and receptive mind.

The third book, *Curious Naturalists*, by Niko Tinbergen, the great animal behaviorist at Oxford University, takes its name from the last chapter, in which the author defends his curiosity about nature. He writes that, ". . . no man need be ashamed of being curious about nature. It could even be argued that this is what he got his brains for and that no greater insult to nature and to oneself is possible than to be indifferent to nature." Tinbergen's curiosity has embraced all forms of animal life—birds, insects, fishes. His studies, only partly reflected in the almost autobiographical essays presented here, have not only

been meticulously detailed, but the deductions he has drawn from them have been experimentally tested to determine their objectivity and their validity. Unlike many naturalists, Tinbergen constructs ingenious methods of testing what he thinks he can deduce from his observations, and, by so doing, is able to present his observations in critically acceptable form. The first essay in this book deals with insect studies at Hulshorst, in Tinbergen's native Holland, where he first found the type of study that he decided to make his life work. This is followed by two chapters on experiences in the arctic, especially in Greenland, where he made his notable studies of snow buntings and phalaropes. Following these are a number of chapters devoted to a variety of creatures—falcons, sand wasps, butterflies, gulls, and ducks, as well as penetrating discussions of both animal camouflage and the symbiotic relations between insects and flowers. All in all, a pleasant and stimulating literary experience is in store for those who read this book.

All three books are well indexed. While this is of less importance in the second and third than in the first volume, the presence of an index indicates to me at least, that the author attempted to make his ideas and his data available to his readers, an attitude always to be commended. Anyone who has had to peruse, page-by-page, old unindexed travel books for the observations of natural history they contain must have had occasions to condemn the authors for this lack of cooperation.

HERBERT FRIEDMANN
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Men and Atoms. The discovery, the uses and the future of atomic energy. William L. Laurence. Simon and Schuster, New York, 1959. xiii + 302 pp. $4.50.

This is a fascinating account, written by the science editor of the New York *Times*, of the birth of the atomic age. Laurence was the only reporter privileged to be in on the secret of the first nuclear bomb before it was exploded above the New Mexico desert in 1945.

Though much of the story has been recorded previously, the reader may enjoy reliving the cloak-and-dagger intrigue that surrounded the Manhattan Project and some of the events of the tense 3½-day countdown that preceded the triggering of the bomb—Bacher struggling with a balky mechanism while he assembled the vital core of the bomb in an old ranch house; Kistiakowsky braving an electrical storm to inspect the bomb-laden test tower; Oppenheimer and General Groves anxiously eyeing the foreboding skies. Then "there rose as if from the bowels of the earth a light not of this world, the light of many suns in one" to herald the end of World War II and the beginning of man's efforts to avoid universal suicide.

Actually, the book covers a great deal more than the Manhattan Project and should give the lay reader, in particular, a good idea of how basic research provides the building blocks for the foundation on which technology lies. This lesson comes through despite the chronologically disjointed narrative (perhaps a reflection of the occupational disease which afflicts us newspapermen) and Laurence's unrestrained prose—sometimes as purplish as the awesome fireball it seeks to describe.

Among other things, Laurence painstakingly debunks the popular notion that the atom-bomb project was sparked by Einstein's famous letter, written in 1939, to President Roosevelt. "The tragic truth is," Laurence says, "that the Einstein letter . . . played no part whatever in the decision (26 months later) to go all out on the building of an atom bomb." For, the author points out, "it was not until December 6, 1941, the day before Pearl Harbor, after the British scientists had shown us that an atom bomb was a definite possibility and when it appeared that we had handed the Germans a head start of three full years (an assumption later proved to be erroneous), that we at last decided to go start work on the project."

As Laurence details our procrastination and lack of top-level concern, the reader should come to realize the implication of two situations: the danger to democratic survival of a scientifically illiterate electorate and, worse yet, the folly of entrusting our national fate, in times such as these, to lawmakers and policy planners ignorant of the ways of science and technology.

The reader should also sense the utter ridiculousness of some of our secrecy rules while, at the same time, recognizing the treacherous cunning of traitors like Fuchs, who breached the tight security precautions to "feed Soviet agents the secrets of the atom bomb and the early theories about the hydrogen bomb."

Undoubtedly, some readers will take issue with the author's discussion of "clean" hydrogen bombs (though he makes it clear they'll never be as pure as Ivory soap), with his defense of our recent nuclear weapons tests (to which I subscribe), and with his conviction that "there cannot be another war" because an aggressor would risk "the certainty of absolute and swift annihilation" (an obvious reality which madmen have a tragic habit of overlooking).

But, all in all, the book is well worth your reading.

JOHN TROAN
Scripps-Howard Newspaper Alliance, Washington, D.C.

Libraries and Bibliographic Centers in the Soviet Union. Indiana University Publications. Slavic and East European series, vol. 16. Paul L. Horecky. Indiana University, Bloomington, 1959. xviii + 289 pp. $3.

Paul Horecky, assistant chief of the Slavic and East European Division of the Library of Congress, characterizes his study as "an attempt to present an up-to-date and realistic picture" of libraries and bibliographic centers in the U.S.S.R. The attempt is timely, worth while, and highly successful. Drawing its information from a wide range of Soviet material and from interviews with American visitors to Soviet libraries, the book has a double merit: it presents a great deal of carefully sifted information about the institutions in question and also points out the rather special role such institutions have been made to play in the Soviet environment. On the factual side, the book describes the Soviet legal deposit-copy system and organs of bibliographic registration and the various aspects of the network of libraries and collections; on the analytical side, the book touches upon the Soviet concept of librarianship as a vehicle for indoctrination.

The well-organized volume begins with a glossary which defines pertinent Soviet terms that often puzzle the nonspecialist, and includes 12 chapters of closely packed data interspersed with elucidating organizational charts, diagrams, and tables. Thirty-four "supplements" containing additional relevant material, a selective and up-to-date bibliography of sources, and a detailed index add to the value of the publication.

The readers of *Science* will be particularly interested in the chapters dealing

with the science and technical libraries, and with the organizational aspects of libraries of the various Soviet academies of sciences.

The book's preface announces a companion volume by Boris Gorokhoff on the abstracting and bibliographic programs of various nonlibrary information services in the Soviet Union. Together, the two volumes should answer most of the pertinent questions for the scientist concerned with Soviet libraries and documentation.

T. W. MARTON
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The Customs and Religion of the Ch'iang. David Crockett Graham. Smithsonian Institution, Washington, D.C., 1958 (Smithsonian Miscellaneous Collections, vol. 135, No. 1). 114 pp. Illus. + plates. $2.

Now that China is closed to social scientists, we are constantly reminded of great gaps in our knowledge of that huge land and its diverse inhabitants. Certain areas of ignorance relate to current problems and their immediate social and political effects. Others seem more obscure and academic until the morning newspaper flashes exotic names and informs us that the center of the crisis-of-our-times is now lodged in Laos, in Tibet, or in the borderlands between China and Burma. Then there is a general shaking-of-heads and much deploring of the shameful limitations of our knowledge.

Such are the thoughts aroused by a reading of this collection of notes about one of the lesser known non-Han peoples of southwestern China. The Ch'iang are people of generally Mongoloid type who speak a Tibeto-Burman language. Those whose culture is described (primarily in its religious aspects) live in western Szech'uan. They are farmers and keepers of domesticated animals, and their clothing as well as their language immediately sets them apart from the Chinese who dwell in nearby valleys and from the other non-Han peoples, the Wa and the Chia-rung, who are their neighbors. The Ch'iang are particularly interesting because the Chinese have long asserted that the Ch'iang are descended from the peoples of Northwest China who, over 2000 years ago, were dislodged and became the fundamental population of Tibet. Graham's notes on Ch'iang religion throw little positive light on this problem, since few resemblances are manifest between Ch'iang religion and Bon-po, the pre-Buddhist religion of Tibet (as opposed to contemporary Tibetan Bon, which is so heavily inroaded with Buddhist elements that it virtually constitutes an aberrant sect of Lamaism). Nevertheless, Graham's book suggests once again a most fascinating problem for a linguist: what light does glottochronology thrown on the question of the Ch'iang-Tibetan relationship and its time depth?

This volume does not pretend to be a complete and unified account of Ch'iang culture but pursues the author's special interest in Ch'iang religious beliefs and ceremonies. It will also be found useful because of its substantial body of Ch'iang texts which appear in phonetic renderings (in Chinese and in English). Graham is to be congratulated for making this material available, and the Smithsonian Institution is to be complimented for providing for its publication.

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Steroids. Louis F. Fieser and Mary Fieser. Reinhold, New York; Chapman and Hall, London, 1959. xvii + 945 pp. $18.

Steroids revises and extends the Fiesers' *Natural Products Related to Phenanthrene* which, in three editions, has been the authoritative text in this field since 1936. The authors' justifications for undertaking a new edition under a different title are the expanded interest in and importance of steroid chemistry in recent years, the introduction of conformational analysis and other theoretical tools into the steroid field, and the organic chemists' need for a reliable guide to recent advances in this intricate subject. Although under the Fiesers' authorship, *Steroids* is a collaborative effort in the sense that no less than 67 outstanding steroid chemists cooperated with the authors by supplying suggestions, corrections, and unpublished advance information (this made it possible for the book to cover current literature to March 1959). The material is presented as a series of separate topics, and each topic is complete in itself, in that the topic is developed from historic to modern dates; early work is interpreted in modern terms. The Fiesers' captivating and readable prose style continues to be strongly evident in the present text.

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New Books

College Physics. Robert L. Weber, Marsh W. White, Kenneth V. Manning. McGraw-Hill, New York, ed. 3, 1959. 645 pp. $7.50.

Electrolytic Conductance. Raymond M. Fuoss and Filippo Accascina. Interscience, New York, 1959. 288 pp. $8.

A Handbook of Colorimetric Chemical Analytical Methods. Tintometer Ltd., Salisbury, England, 1959. 30s.

International Review of Cytology. vol. 8. G. H. Bourne and J. F. Danielli, Eds. Academic Press, New York, 1959. 551 pp. $13. Contents: "The structure of cytoplasm," "Wall organization in plant cells," "Submicroscopic morphology of the synapse," "The cell surface of *Paramecium*," "The mammalian reticulocyte," "The physiology of chromatophores," "The fibrous components of connective tissue with special reference to the elastic fiber," "Experimental heterotopic ossification," "A survey of metabolic studies on isolated mammalian nuclei," "Trace elements in cellular function," "Osmotic properties of living cells," "Sodium and potassium movements in nerve, muscle, and red cells," and "Pinocytosis."

International Review of Neurobiology. vol. 1. Carl C. Pfeiffer and John R. Smythies, Eds. Academic Press, New York, 1959. 395 pp. $10.

An Introduction to Electronic Data Processing. Roger Nett and Stanley A. Hetzler. Free Press, Glencoe, Ill., 1959. 287 pp. $6.75.

Kinematic Analysis of Mechanisms. Joseph Edward Shigley. McGraw-Hill, New York, 1959. 361 pp. $7.75.

Lectures on Fourier Integrals. Salomon Bochner. With an author's supplement on monotonic functions, Stieltjes integrals, and harmonic analysis. Translated from the original by Morris Tenenbaum and Harry Pollard. Princeton Univ. Press, Princeton, N.J., 1959. 341 pp. Paper, $5.

A Manual for Histologic Technicians. Ann Preece. Little, Brown, Boston, Mass., 1959. 228 pp.

Mathematical Programming and Electrical Networks. Jack B. Dennis. Technology Press and Wiley, New York; Chapman and Hall, London, 1959. 192 pp. $4.50.

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Protein and Amino Acid Nutrition. Anthony A. Albanese, Ed. Academic Press, New York, 1959. 616 pp. $16.

Races and People. William C. Boyd and Isaac Asimov. Abelard-Schuman, New York, 1959. 189 pp. $2.75.

Reports

Dissipation of Planetary Atmospheres

Abstract. Escape-level density is approximately inversely proportional to gravity and with decreasing mass will tend toward that of interplanetary gas. When this value is reached, dissipation must cease. The minimum possible ground density of lunar air is calculated to be 10^{-12} that of the air at normal temperature and pressure. Ionization creates a binding electrostatic charge at the escape level.

Jeans' theory of molecular dissipation is of fundamental importance to the study of planetary atmospheres (*1*). It applies, however, to a greatly simplified atmospheric model and leaves many important aspects of the situation out of account.

Jeans considers an atmosphere in isothermal equilibrium which thins out upward according to the formula

$$\rho_z = \rho_0 e^{-2hmga\,[z/(a+z)]} \qquad (1)$$

where ρ_z is the atmospheric density at a height z above the surface of the planet; ρ_0 is the atmospheric density at ground level; e is the base of natural logarithms; h is $1/2RT$ (R being the gas constant and T the absolute temperature of the atmosphere, which is the same throughout by definition); m is the mean molecular weight of atmospheric gases; g is the surface gravity; and a is the semidiameter of the planet in question.

Now, a real planetary atmosphere is not even approximately isothermal, and Jeans' treatment is significantly wrong, as has been pointed out by Lyman Spitzer, Jr., (*2*), by reason of the difference in the temperature of the atmosphere at ground level and at the escape level where molecular collisions become so infrequent that they can be neglected in practice and where any molecule having an outward or "positive" velocity equal to or exceeding the velocity of escape will be lost to space.

It is clear that the actual rate of dissipation will depend on the conditions obtaining at the escape level; of these conditions, Spitzer considers only the temperature. There are three further important factors, which I will take up seriatim.

1) Let ρ be the atmospheric density at the actual escape level. In the atmosphere of a body of small attracting mass, this critical density will be reached at a greater height, both because of the flatter density gradient and because of the more marked drop in gravity over the increased height itself.

The important point, however, is that ρ will not be the same for different values of g, for the operative condition which any given atmospheric level must satisfy to be the escape level is that molecular collisions above it are so infrequent that they can be neglected in practice, which means that the number of molecules above it must be substantially the same in every case. ρ is proportional to the pressure p and *ceteris paribus* the latter is proportional to g, so that, to satisfy the above requirement, ρ must be inversely proportional to g.

Since, though, the rate of molecular dissipation per unit area must be proportional to ρ, it, too, will be inversely proportional to g at the escape level. In the particular case of the moon this means that the rate of dissipation assumed by Jeans is at least 6 times too high.

2) The atmosphere at escape level will be unshielded against short-wave radiations and exposed to bombardment by cosmic rays, so that it must be highly ionized. This will increase its molecular density ν, even though ρ remains the same, by increasing the number of free particles. The number of collisions will increase *pari passu*, so that the effective escape level will rise and the rate of escape will drop, although this effect will be counteracted by a fall in m, to which the rate of escape is very sensitive (*1*).

In such ionized gas, or plasma, every electron becomes an independent particle with a mass of about 1/1800 that of a hydrogen atom. The square of mean molecular velocity, $C^2 = 3RT/m$, and free electrons will be lost very quickly at the escape level. In view of their low collisional cross-section, they may be taken to diffuse equally up and down from the escape layer, so that one-half of all free electrons produced there will be lost to space and the other half to the immediately subjacent layer of the atmosphere.

As a result, the escape layer will acquire a strong positive electrostatic charge, and the underlying layer will become negatively charged. Thus we have here something like an electrophorus, whose charge will tend to grow up to a certain maximum, depending on the degree of ionization.

This, however, must generate a considerable electrostatic force binding the escape layer to the subjacent atmosphere. It will, of course, also tend to increase the density of this layer and, while the numerical consequences of this situation remain to be determined, it appears likely that the exosphere has a well-defined boundary, as indeed rocket data would seem to indicate.

3) It is usually assumed that interplanetary space is a perfect vacuum, but this is hardly true within the present terms of reference. Indeed, the molecular density of the interplanetary gas in the vicinity of the earth is about $10^3/cm^3$ (*3*).

This gas will offer some collisional opposition to the escape of atmospheric molecules and be itself subject to gravitational and electrostatic capture. The increment from this source may be not inappreciable, and for thin atmospheres it may become decisive.

We have seen under (*1*) that the rate of escape depends on the molecular density ν at the escape level, which decreases with the mass of the attracting body. In doing this it will steadily draw closer to the molecular density of the interplanetary gas, which will be able to offer an increasingly effective resistance to atmospheric dissipation.

No certain data are available here, and this reasoning is not exhaustive, but it is worth pursuing and leads to a somewhat paradoxical situation, for once ν has dropped to the density of interplanetary gas, dissipation becomes impossible. In other words, *the atmosphere of a body of sufficiently small mass becomes indestructible.*

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

The critical mass is yet to be determined, but it appears that asteroids may be able to retain appreciable gaseous envelopes which they could have acquired by gravitational and electrostatic capture of interplanetary gas, its concentration by sorption on their surfaces [particularly effective if their surfaces are porous or dust-covered (*4*)], and radioactive decay of their lithosphere and the liberation of such gases as may be occluded in it. Yet such atmospheres would be substantially lost by more massive bodies.

Even so, the latter could not lose their atmospheres completely, for the agencies mentioned above will be at work on them as well. There must, therefore, exist a lower limit below which the ground atmospheric density cannot fall. This limit will depend on a host of factors, too numerous and too uncertain for generalization in useful mathematical terms. If, however, gravitational action is considered alone, the limiting ground density can be readily determined in the known case of the moon. The accuracy of such an estimate cannot go beyond the order of magnitude, so that there would be no point in more than a rough numerical calculation.

Let us assume that the moon is surrounded by an isothermal atmosphere obeying Eq. 1 at a temperature $T = 250°K$ and having a mean molecular weight 25 (it would be much higher in reality). By definition, this atmosphere is due solely to the gravitational concentration of interplanetary gas, the molecular density of which may be taken to be the same as it is in the vicinity of the earth, that is, about 10^3.

The atmosphere of the earth is known to extend in attenuated form up to 1000 km or so. That of the moon should extend farther out, owing to the lower surface gravity. To be on the safe side, we may take 1000 km $= 10^8$ cm as the upper limit z of this lunar atmosphere and put $g = 150$ cm $\cdot$ sec^{-2} (below the real value).

Equation 1 may be written thus:

$$v_z = v_0 e^{-2hmga\,[z/(a\,+\,z)]} \qquad (2)$$

where v_z is the molecular density at z and v_0 is the molecular density at ground level. Our problem is to find v_0.

$$v_0 = v_z e^{2hmga\,[z/(a\,+\,z)]} \qquad (2)$$

Numerically, putting $R \simeq 8 \times 10^7$ and $a \simeq 10^8$ cm,

$$v_0 = 10^3 \times e^{150/16}$$

whence, upon carrying out the operations, v_0 is approximately 1.9×10^7.

The molecular density of any gas at normal temperature and pressure on the earth is given by Loschmidt's number $n = 2.69 \times 10^{19}$. Thus the ground density of lunar air resulting solely from the gravitational concentration of interplanetary gas would be of the order of 10^{-12} the terrestrial atmospheric density at sea level. It will be appreciated that this represents only the lowest possible limit, for it has been assumed above that the moon has never had any atmosphere of its own, that no gases, produced by radioactive decay or any other physicochemical processes or by meteoritic impacts, are liberated from its interior. The concentration of gas close to the lunar surface by the sorptive action of dust and porous pumice-like rocks of which this is expected to consist (*4*) is likewise disregarded. Moreover, if a convective atmospheric layer exists above the surface of the moon its density gradient will be higher than in the assumed isothermal atmosphere (*2*, *4*).

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4 May 1959

Escape and Avoidance Conditioning in Human Subjects without Their Observation of the Response

Abstract. An invisibly small thumb-twitch increased in rate of occurrence when it served, via electromyographic amplification, to terminate or postpone aversive noise stimulation. Subjects remained ignorant of their behavior and its effect. Their cumulative response curves resembled those obtained in similar work with animals. Other subjects, informed of the effective response, could not produce it deliberately in a size small enough to qualify for reinforcement.

When the human subject has "voluntary control" of the response to be conditioned, experimental results are in general less predictable and reproducible than those obtained from animals. This is commonly attributed to "self instruction"—that is, to variables experimentally uncontrolled. In the study reported here this problem was circumvented by working with a response so small as to preclude a history of strengthening through discriminable effect upon the environment—in fact, so small as to occur unnoticed by the subject.

The electromyographic setup employed was a modification of that previously reported (*1*). The subject sat in a shielded enclosure in a reclining chair. Recording electrodes were attached to the palmar base of the left thumb and to the medial edge of the left hand. Three additional sets of dummy electrodes were applied in some instances, to suggest that a comprehensive study of body tensions was being conducted. Muscle-action potentials across the left hand were amplified by a factor of 1 million and rectified, and their average momentary values were displayed on a meter. They were also permanently recorded by an Esterline-Angus recording milliammeter.

Twenty-four adults served as subjects. Records from 12 were ruined by apparatus failure, excessive artifact, or failure of the subject to sit still. Results are reported from eight men and four women ranging in age from 18 to 50 and divided into four groups of three each.

Group 1, with four sets of electrodes attached, were told that the study concerned the effects on body tension of noise superimposed on music. Their task was to listen through earphones and, otherwise, do nothing. Group 2, also with all electrodes attached, were told that a specific response, so small as to be invisible, would temporarily turn off the noise or, when the noise was not present, postpone its onset. Their task was to discover and make use of the response. Group 3 (with recording electrodes only) were informed that the effective response was a tiny twitch of the left thumb. Group 4 were given the same information as group 3 but had, in addition, a meter before them during the first half-hour of conditioning, which provided a potential basis for them to use the visual presentation of their response as a "crutch" for proprioceptive observation of the response.

Experimental procedure was identical for all groups. While the subject relaxed and listened to tape-recorded music through earphones, the experimenter watched the meter on his panel for 5 to 10 minutes to select for later reinforcement a response of a size occurring not more than once in 1 or 2 minutes. It was a ballistic swing of the pointer up and back over a few scale divisions. This represented, for a particular subject, a momentary voltage increment at the electrode of 1, 2, or 3 μv.

After the operant level for this response had been recorded for 10 minutes (*OL 1* in Fig. 1), conditioning was begun by superimposing on the music an aversively loud, 60-cycle hum.

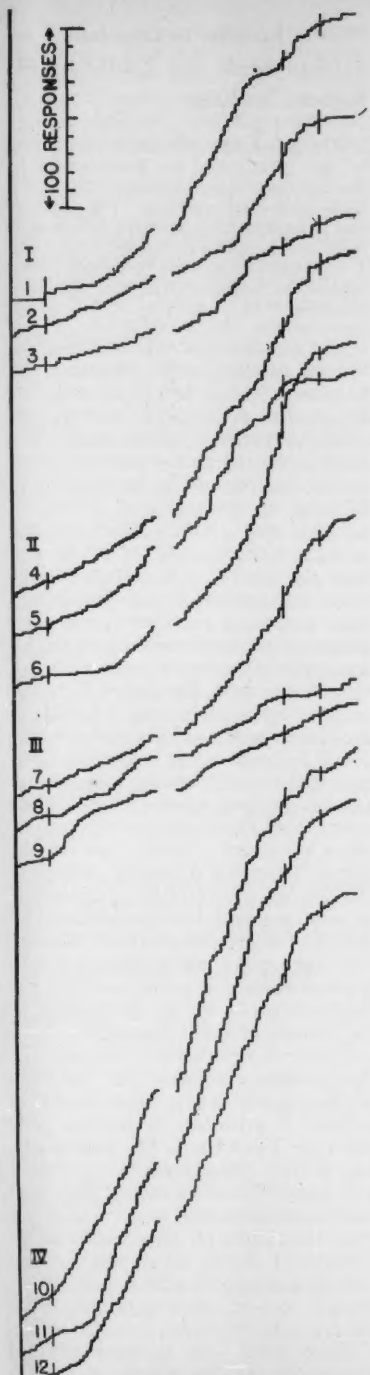

Fig. 1. Cumulative response curves for adult human subjects in a situation where an invisibly small and unnoticed thumb-twitch either terminated or postponed noise stimulation. *OL 1* and *2*, initial and terminal operant level determinations, respectively; *ex.*, extinction.

Whenever the experimenter saw on the meter an instance of the selected response, he pressed a key. This turned off the noise for 15 seconds or, when it was already off, postponed noise resumption for 15 seconds. [This type of avoidance schedule, mentioned in 1950 (*2*), has been extensively employed by Sidman in animal work (*3*).]

After an hour of conditioning, with a 5-minute intermission at the half-hour point, 10 minutes of extinction occurred during which the subject's response was ineffective in terminating continuously present noise. During final 10 minutes of music only, the extent of recovery of the original operant level was recorded.

Figure 1 presents cumulative response curves for each subject. Conditioning is clearly indicated by the positive acceleration in the rate of responding for all subjects except subjects 2 and 3 in group 3. These two kept so busy producing voluntary thumb-twitches that the small, reinforceable type of response had little opportunity to occur.

When interviewed later, all members of group 1 still believed that they had been passive victims with respect to the onset and duration of noise, and all seemed astounded to learn that they themselves had been in control. Subjects 1 and 2 of group 2 reported that they early gave up searching for an effective response and thus, in effect, transferred themselves to group 1. Subject 3 of group 2 professed to have discovered an effective response sequence, which consisted of subtle rowing movements with both hands, infinitesimal wriggles of both ankles, a slight displacement of the jaw to the left, breathing out—and then waiting. Subject 1 of group 3 gave evidence of conditioning perhaps because he misconstrued the instructions. Instead of making the response a quick contraction, he spent his time very gradually increasing pressure on an imaginary switch button. This may have kept deliberate activity at a level low enough for the correct response to break through and be reinforced.

Group 4 subjects, provided with their own meter, obtained many more reinforcements than the others, an effect which continued through the second half-hour of conditioning, with the meter removed. While the meter did not enable them to achieve direct control of the discrete response, it seems to have provided a basis for rapid responding within a range which included the reinforced size. This showed on the meter as rapid oscillation.

The technique employed in this study (*4*) offers possibilities for investigating human behavior, in a sense, at the animal level. Research now in progress is concerned with attempts to clarify the circumstances under which the human subject may come to discriminate verbally—that is, to become conscious of—his small responses.

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4. This investigation was supported by research grant M-2961, National Institutes of Health, U.S. Public Health Service, and by grants from the Higgins Fund and the Columbia University Council for Research in the Social Sciences.

16 July 1959

Elementary-Body Virus Isolated from Clinical Trachoma in California

Abstract. From an adult white resident of California with clinically typical early trachoma a virus was isolated by growth in embryonated eggs. Morphologically and serologically the virus belongs in the psittacosis-lymphogranuloma group. When it is instilled into monkey eyes it produces acute follicular conjunctivitis with typical inclusion bodies.

It is estimated that over 400 million people, mainly in Africa, Asia, and parts of Europe, suffer from trachoma as a serious eye disease. In the United States this disease was widespread in the past, but at present it occurs only at a low endemic level, most frequently in the West and Southwest. In San Jose, Calif., indigenous clinical cases of trachoma occur occasionally.

On morphological grounds the elementary bodies and inclusion bodies found in the conjunctival scrapings from many patients with trachoma have long been accepted as the probable etiological agent. Recently T'ang *et al.* (*1*), Collier and Sowa (*2*), and Murray *et al.* (*3*) have grown from trachomatous eyes in China, Gambia, and Arabia, respectively, strains of elementary-body viruses antigenically related to the psittacosis-lymphogranuloma group. Upon inoculation into the eyes of volunteers, some of these viruses have produced typical acute trachoma (*2*). We report here the isolation of a similar agent from a patient with clinical trachoma in California.

A 36-year-old white machinist, a long-time resident of San Jose, developed a red left eye on 10 Jan. 1959, with moderate yellow discharge and a nontender left preauricular lymph node.

Fig. 1. Inclusion body in epithelial cell of patient's conjunctiva.

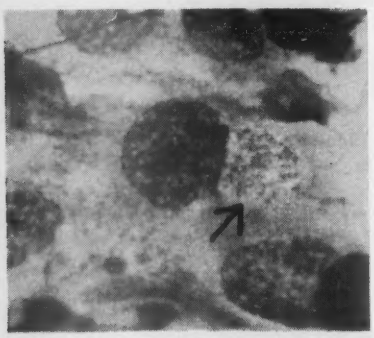

Fig. 2. Inclusion body in conjunctival epithelial cell of *Macacus cynomolgus* inoculated three days earlier with sixth-egg-passage virus (Bour).

His physician prescribed 1-percent chloramphenicol eyedrops, which he instilled for the next 26 days, with some symptomatic improvement. On 12 February a similar conjunctivitis developed in the right eye, with marked photophobia. Neomycin-polymyxin eyedrops were administered for 4 days. On 16 February the inflammation in the left eye suddenly increased markedly, and gross keratitis appeared. Clinical examination on 17 February revealed bilateral papillary hypertrophy, with buried follicles of the upper tarsi, microscopic pannus and corneal infiltrates, and palpable preauricular lymph nodes. Scrapings from the upper tarsal conjunctivas showed many inclusions typical of trachoma (Fig. 1). Bacterial cultures were negative. The patient was treated with topical tetracycline and oral methylsulfapyridazine (500 mg daily) from 19 Feb. to 15 Apr. 1959, with gradual disappearance of all clinical and microscopic signs of trachoma. At present he appears healed.

Conjunctival scrapings were collected on 17 and 19 February in broth-saline containing streptomycin (1000 μg/ml) (*1*, *2*). After 1 hour at 4°C they were injected into the yolk sac of 6- and 8-day-old embryonated eggs. In this first egg passage there was no mortality, and no elementary bodies were seen in smears of the yolk sac stained in accordance with Macchiavello or Giemsa techniques. Elementary bodies were seen in five of six eggs of the second passage sacrificed on days 9 and 10 after inoculation. In the third egg passage all embryos died between the fourth and the eighth day after inoculation, and elementary bodies were seen in profusion. At present this virus strain (Bour) in the seventh egg passage has an egg LD_{50} of $10^{-4.5}$. The elementary bodies conform in size and staining properties with those grown by others from trachoma patients (*1–3*). Four monkeys (*Macaca cynomolgus*) were inoculated in one eye with a 20-percent yolk-sac suspension of sixth-passage virus and in the other eye, with normal yolk sac. Two to six days later they all developed follicular conjunctivitis, and conjunctival scrapings contained many typical inclusion bodies (Fig. 2).

The patient's serum, drawn on 19 February, fixed complement in a 1:64 dilution with psittacosis or Lygranum antigens. Antigens prepared from a yolk-sac pool of virus (Bour) fixed complement with antisera to psittacosis virus (*4*).

This appears to be the first isolation of an elementary-body virus of the psittacosis-lymphogranuloma group ("trachoma virus") from a typical case of trachoma arising in the United States. Many intriguing questions are now under study, including the relationship of this virus (Bour) to inclusion blennorrhea and to the elementary-body viruses isolated from trachoma in other parts of the world, the toxin production and pathogenetic potential of this agent, and its biological and epidemiological characteristics (*5*).

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4. The antisera was provided through the courtesy of B. Eddie.
5. This work was supported by grants from the National Institutes of Health (B-604), the Burroughs Wellcome Fund, and the Research Committee of the University of California.

6 July 1959

Growth Inhibitor in Immature Soybean Seeds and 2,4-D-Sprayed Soybean Seedlings

Abstract. A naturally occurring inhibitor of seed germination has been isolated by ion-exchange chromatography from soybean seeds and seedlings. The inhibitor was present in large amounts in immature seeds and in seedlings sprayed with 2,4-D. The inhibitor acted as an "uncoupler" when applied to soybean root tips or mitochondria.

Our concurrent studies on the inhibition of germination in immature soybean seeds (Galitz) and on the inhibition of growth in soybean seedlings by 2,4-dichlorophenoxyacetic acid (2,4-D) (Key) indicated that a common compound was responsible for the two inhibitions. In the studies of growth inhibitions that resulted from spraying seedings with $5 \times 10^{-4}M$ 2,4-D, soybean hypocotyls were extracted with 0.6*M* cold perchloric acid. The extracts were cleared of perchlorate and chromatographed on Dowex-1-formate for separation of nucleotide components (*1*). One elution peak (designated *C* in this report) increased about twofold in seedlings which had been sprayed with 2,4-D 24 hours before extraction. Compound *C* eluted from the ion-exchange column between adenosine monophosphate and guanosine monophosphate when a gradient of formic acid was the eluent. There was a positive correlation between the concentration of compound *C* and the growth inhibition induced by 2,4-D. Further investigation showed that compound *C* was present in mature soybean seeds and young seedlings but declined rapidly during germination in the absence of 2,4-D treatment.

Galitz (*2*) reported the presence of a water-soluble inhibitor in immature soybean seeds. These seeds could be induced to germinate by leaching with water for 2 to 4 hours. The leachate obtained from these seeds would retard elongation of radicles excised from mature seeds. Immature seeds were therefore investigated for the presence of *C*.

Figure 1 shows the elution chromatogram of perchloric acid extracts of immature soybean seeds collected 25 to 30 days after flowering. The dry weight of such seeds was approximately 25 percent of the dry weight of mature seeds. Compound *C* accounted for over 50 percent of the 260-mμ absorbing material. Compound *D* appeared to be derived from *C* during extraction, for, if the perchloric acid extracts were held overnight at 2° to 4°C, there was a loss of *C* and an increase in *D*. The amount of *C* in immature seeds was 2 to 3 times as great as in mature seeds; on a dry-weight basis the concentration

was 8 to 10 times higher. Immature seeds which were leached in water for 3 hours lost over half of the *C* initially present. Compound *C* was the only fraction obtained from the perchloric acid extracts which was an effective growth inhibitor.

For inhibition studies, compound *C* was isolated from immature soybean seeds or frozen green peas (a readily available source of material) by ion-exchange chromatography, as illustrated in Fig. 1, then lyophilized to remove the formic acid. The dried residue was dissolved in water and adjusted to *p*H 5.0 with KOH. Concentrations are expressed in terms of optical density at 260 mμ. One "O.D. unit" is that amount of *C* which will give unit optical density in 1 ml of solution with 1-cm cuvettes in the Beckman DU spectrophotometer.

Table 1 gives data for the effect of compound *C* on seed germination, on root respiration and phosphate accumulation, and on oxidative phosphorylation by mitochondria isolated from soybean hypocotyls. Mature soybean seeds were soaked in the indicated concentrations of *C* for 4 hours and then planted in moist vermiculite. Germination of treated seeds was delayed 24 hours as compared with germination of controls soaked in water. After 48 hours, 60 to 90 percent of the treated seeds had germinated. The mean length of the embryonic axis of the seeds that germinated is given in Table 1. Similar responses to compound *C* were obtained with mature corn seeds.

Table 1. Effects of compound *C* on germination of soybean seeds and on the respiration and phosphate uptake of soybean root tips and isolated soybean hypocotyl mitochondria.

Germination of soybean seed			
Units of *C* per 4 ml of water	0	1	10
Length of plant (in cm) (after 48 hours)	4.5	2.5	2.0
*Activity of 1-cm soybean root tips**			
Units of *C* per 2.5 ml of buffer	0	5	25
Respiration, initial 15 minutes	780	830	1670
Respiration, after 3 hours	753	809	943
PO_4 uptake, after 3 hours	0.31	0.26	0.21
Activity of soybean mitochondria†			
Units of *C* per 2.5 ml of buffer	0	1	15
$Qo_2(N)$	917	885	702
P/O	2.69	2.27	2.08
P/N	221	179	130

* Root tips were placed in Warburg vessels in $10^{-3}M$ potassium phosphate (*p*H 5.0) labeled with P^{32}. Respiration rate is given as microliters of O_2 per hour per gram (fresh weight); phosphate uptake is given as micromoles of PO_4 absorbed per gram (fresh water).

† Mitochondria were isolated and activity was determined over a 30-minute period with α-ketoglutarate as the substrate (*8*). $Qo_2(N)$ is given in microliters of O_2 per hour per milligram of N; P/O is given in micromoles of P esterified per microatom of O_2; P/N is given in micromoles of P esterified per hour per milligram of N.

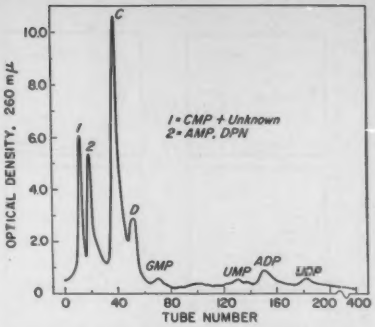

Fig. 1. Elution spectrum of soluble nucleotides from immature soybean seeds. Seeds were homogenized in 0.6*M* $HClO_4$ and centrifuged, and the perchlorate was removed from the extract as the K salt. The extract was placed on Dowex-1 (formate) and eluted with a gradient of formic acid-ammonium formate (*1*). ADP, AMP, adenosine di- and monophosphate; CMP, cytidine monophosphate; DPN, diphosphopyridine nucleotide; GMP, guanosine monophosphate; UDP, UMP, uridine di- and monophosphate.

The application of 25 O.D. units of compound *C* to root tips caused the respiration rate to increase markedly in the initial 15 minutes; this increase was followed by a gradual decline to rates comparable to control levels after 1 hour. Table 1 shows respiration rates and the amount of orthophosphate accumulated by the tissue in 3 hours. The net result in increased respiration and in decreased phosphate accumulation was similar to that produced by the uncoupling agent, 2,4-dinitrophenol.

Further evidence that compound *C* acts as an uncoupler was given in the experiments with mitochondria. Phosphate esterification per unit N was inhibited. Oxidation of α-ketoglutarate was generally depressed, as indicated in Table 1, although in occasional experiments a transitory increase in respiration was noted.

It will be noted in Fig. 1 that no triphosphate nucleotides were obtained from immature seeds. Extracts of hydrated mature seeds contained appreciable amounts of triphosphate nucleotides, particularly adenosine triphosphate. This finding and the evidence that compound *C* is an uncoupler of oxidative phosphorylation (Table 1), suggest that *C* acts as a growth inhibitor, at least in part, through inhibition of high-energy phosphate production.

The concept that endogenous inhibitors control seed germination is widely held (*3*), and Evenari (*4*) has listed over 100 species from which germination inhibitors have been obtained. Compound *C* may be an important inhibitor of germination in immature seeds. Woodford *et al.* (*5*) and van Overbeek *et al.* (*6*) have suggested that the growth inhibitions caused by high auxin concentrations may result from the accumulation of growth inhibitors. The experiments reported here (*7*) indicate that the inhibitory effects of 2,4-D applied to soybean seedlings may be the result of the accumulation of *C*.

Work on the chemical identification of compound *C* is in progress. Studies are also being made of the distribution of this compound in various species of immature seeds and of its relationship to seed germination.

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15 June 1959

Discrimination Learning

Abstract. Eight rats were run through discrimination training sessions in which responses in the dark were not reinforced whereas the first response after the onset of a light was reinforced. The procedure generated orderly learning and latency data for the individual animal. The latency distributions are adequately described by a simple mathematical formulation.

The present study was designed, first, to determine the extent to which orderly discrimination learning curves for individual animals could be simply obtained and, second, to test the adequacy of a mathematical formulation developed by Mueller (*1*) for describing latency data.

The subjects were eight naive, adult, male albino rats which had been deprived of water for 22½ hours at the start of each experimental session. The apparatus consisted of a response chamber through one wall of which a

response lever was inserted. Depression of this lever could activate a dipper which delivered the reinforcement, a drop of water. A stimulus light was mounted directly above the lever. The response chamber was housed in a sound-shielded, light-proof room in which a random noise generator masked external sounds. The programing and recording devices were housed in a separate room.

Each rat was first given a ½-hour operant level session—that is, a session in which it had free access to the lever but in which no reinforcements were delivered. Each rat was then trained to approach and drink from the dipper on hearing it operate and, subsequently, to depress the response lever to operate the dipper. Once the animal had learned to press the lever, it was given three sessions during which each response was reinforced (a total of 375 reinforcements). The stimulus light was on throughout each of these sessions.

The procedure was then changed so that the animal, in order to receive reinforcements, was required to make a discrimination—that is, to respond when the stimulus light was on and not to respond when the stimulus light was off. Each response recycled a timer set for a 20-second interval. When this time had elapsed, the light came on in the response chamber. The first response in the light activated the dipper, which delivered a drop of water, turned out the light, and recycled the timer. A response in the dark, on the other hand, recycled the timer but did not operate the dipper. Thus, the onset of light was always 20 seconds after a response; an animal that never spaced its responses at least 20-seconds apart received neither a presentation of light nor a response reinforcement (*2*). Ten daily 1-hour sessions of discrimination training were given. The time that elapsed between each onset of light and the subsequent response was recorded in sessions 9 and 10.

Fig. 1. Discrimination indices for each rat in each session. The animal's number appears in each graph.

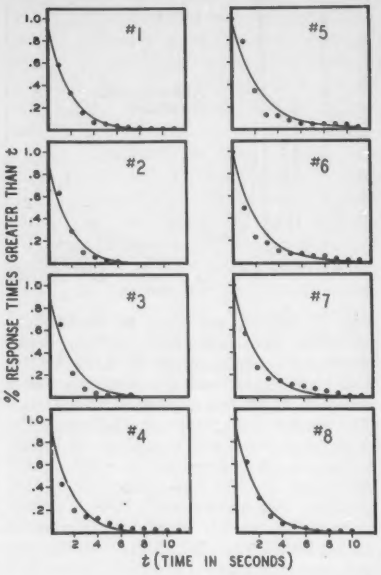

Fig. 2. The proportion of latencies (time from onset of light to time of response) greater than t plotted for each rat in session 10. The curves describe the equation e^{-rt}, where r is the reciprocal of the mean latency.

The response data are treated in terms of a "discrimination index" computed for each rat in each session. This index of learning is the ratio of the number of responses made in the light to the total number of responses (those made in the light plus those made in the dark). As the animal learns, an increasingly large proportion of the total number of responses occurs in the light; the index can accordingly shift from 0 to 1 as learning progresses (*3*). Such discrimination indices, plotted for each rat, are shown in Fig. 1.

With each occurrence of an interresponse time of at least 20 seconds, the stimulus light appeared and, within a brief period, the animal depressed the lever. The procedure provided, then, latencies measured as time from onset of light to time of response. The latency distributions obtained in session 10 are plotted in Fig. 2.

The values plotted are the proportions of responses made after various times t on the abscissa. If an animal emitted ten responses with a latency of 1 second, ten with a latency of 2 seconds, and ten with a latency of 3 seconds, for example, the corresponding proportions would be 1.00, 0.67, 0.33, and 0, plotted against t values of 0, 1, 2, and 3 seconds, respectively. The curves drawn through the points describe the equation $Y=e^{-rt}$, where Y is the proportion of response times greater than any time t, r is the reciprocal of the mean latency, and e is the natural base of logarithms.

This equation is one developed by Mueller (*1*) on the assumption that responses are randomly distributed in time. In his treatment, r corresponds to the response rate developed in a "free responding," operant situation; that is, the value of r is given by the ratio of the number of responses made to the total time available for responding. In the present context, then, r is equal to the reciprocal of the mean latency (*4*). The curves plotted in Fig. 2 were drawn by computing the reciprocal of the mean latency, substituting this value in the e^{-rt} equation for the various t values, and plotting the resultant Y values (*5*). These data and the details of procedure have been more completely described elsewhere (*6*).

Figures 1 and 2 indicate that the procedure generated rather orderly learning and latency data for the individual animal. It may therefore be of some value in assessing the effects of various independent variables on these kinds of behavior in the single animal, as opposed to behavior in some arbitrary, "average" organism. Further, the general adequacy of the e^{-rt} equation in describing the data of Fig. 2 (*7*) suggests that this equation could be useful as a starting point for the development of mathematical descriptions of certain more complex forms of behavior.

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2. This general procedure was originated by D. M. Page [cited in M. P. Wilson and F. S. Keller, *J. Comp. and Physiol. Psychol.* **46**, 190 (1953)].
3. These indices are a rather gross composite of at least three variations in the animal's behavior. (i) With training, the animals presumably come to respond more rapidly after the onset of the light and thus "gain" further opportunities for presentation of light. (ii) As the discrimination is learned, fewer responses are made in the dark, and thus more occasions are provided for presentation of light and subsequent responses. (iii) The indices are affected by the distribution, in time, of those responses that are made in the dark; for example, responses made after 19 seconds of darkness decrease the total number of opportunities for presentation of light more than do those made after 5 seconds.

4. In an operant situation, r is equal to N/T, where N is the number of responses and T is the time available for responding. Here, N equals the number of responses in the light and T the sum of all latencies. The mean latency is thus T/N, and its reciprocal is r.
5. A more sensitive, and therefore preferable, way of treating latency (L) data is in terms of the ratios of the frequency of any L to the number of opportunities for that L to occur. The limitations of the present experiment, however, were such that the difficulties inherent in the use of this ratio could not be overcome. [See D. Anger, *J. Exptl. Psychol.* **52**, 145 (1956)]. The e^{-rt} function is here taken as a fairly acceptable first approximation to the data.
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7. In the study discussed here the latencies between successive responses made during the preliminary sessions, when each lever depression was reinforced, were not recorded. Data from another, unpublished, study suggest, however, that the e^{-rt} function, when allowance is made for the time the animal spends consuming the water (reinforcement), provides an adequate description of the distributions obtained under these conditions.

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15 July 1959

Role of Trehalose in Ascospores of Neurospora Tetrasperma

Abstract. The anthrone-positive material extractable in 80 percent alcohol, whose disappearance is correlated with the breaking of dormancy, has been found to be a non-reducing sugar which yields only glucose upon hydrolysis. On the basis of its crystal structure, infrared spectrum, melting point, specific rotation, and chromatographic properties, this material has been identified as trehalose.

Ascospores of *Neurospora* remain dormant unless provided a heat-shock (*1*), furfural or furfuryl alcohol (*2*), other furans and heterocyclic compounds (*3*), or certain organic solvents (*4*). Activation of these cells is accompanied by a 20-fold increase in respiratory rate (*5*), the origin of which is still uncertain. Our recent data have revealed that whereas the dormant ascospore utilizes endogenously contained lipids as the respiratory substrate, activated ones consume an endogenous carbohydrate fraction which is extractable in 80 percent ethanol (*6*). Thus, within a few minutes after exposure to temperatures which break dormancy, this material begins to disappear, and it is almost completely exhausted by the time the germ tube is protruded. The present report concerns the analysis of the carbohydrates in the 80-percent-ethanol-soluble fraction and the identification of the principal component as the non-reducing disaccharide trehalose.

Weighed aliquots of ascospores were killed by boiling in 80 percent ethanol for 5 minutes and then were centrifuged free of the supernatant fluid. The spores were broken in a Nossal disintegrator (*7*) and defatted by extraction in ethyl ether for 24 hours. The defatted cells were extracted in 80 percent ethanol at 60°C until no more anthrone-positive material could be removed, after which the supernatant was clarified by centrifugation. The extract was decolorized by mixing with Norit (1 percent by weight) at 60°C; this process was followed by boiling for 15 minutes. After removal of the Norit, the extract was concentrated under a vacuum until a thin syrup was obtained, which was added to a mixed-bed resin containing Dowex 50 (H^+) and Dowex 1 (CO_3^-). Approximately 95 percent of the anthrone-positive materials were recovered by washing the resin with deionized water, and the clear solution was concentrated into a thick syrup, in a vacuum. The syrup was put in a beaker, and an equal volume of hot 80 percent ethanol was added; the beaker was placed in a desiccator at 4°C, and crystals formed within 24 hours. When left undisturbed in the cold for 3 weeks, most of the liquid evaporated and large numbers of clear orthorhombic crystals formed, some as large as 4 by 2 mm. These crystals were redissolved in hot 80 percent ethanol, recrystallized, washed again in cold ethanol, and dried under a vacuum. The yield, on the basis of dry weight of ascospores, was 10.2 percent; this represented approximately 78 percent of the anthrone-positive materials in the 80-percent-alcohol extract.

Various analyses of the crystalline material were carried out, including chromatography with N-butanol, acetic acid, and water (4:1:5) as a solvent system, and a single spot was found which corresponded to trehalose. The periodate-permanganate reagent of Lemieux and Bauer (*8*) was used, and the length of time required for the development of the spot was found to be identical for the material obtained from the ascospores and for an authentic sample of trehalose. Therefore, the characteristics of the crystals obtained from the ascospores were compared with those of authentic trehalose; the data are summarized in Table 1. In addition, the infrared spectra of these two samples were found to be identical when Nujol mulls were observed in a Perkin-Elmer model 21 spectrograph (*9*). Finally, the crystalline material was found to be nonreducing and liberated only glucose upon hydrolysis in 1*M* H_2SO_4, as revealed by analysis with the glucose oxidase system (*10*).

Extracts that had not been passed through the resins yielded another spot upon being chromatographed. Such material, when concentrated, formed not only the rhomboidal crystals of trehalose but a small number of needle-shaped crystals as well. This second substance was found also to be nonreducing, but it did not give the blue-green color with anthrone. For these reasons, and because its R_f in the solvent system described above was identical with that of mannitol, it was tentatively identified as that sugar-alcohol.

Table 1. Comparison of properties of extract from ascospores of *Neurospora tetrasperma* and trehalose.

Property	Ascospore extract	Trehalose
Melting point	97°–99° and 205°–210°	96.5°–97.5° and 203°*
Mixed melting point	97°–99° and 203°–206°	
$[\alpha]_D^{20}$	+176	+176
R_f in butanol, acetic acid, and H_2O	0.06	0.06

* Data from (*12*).

These data suggest that trehalose is probably the substrate, soluble in 80 percent ethanol, whose utilization is correlated with the activation of ascospores of *Neurospora tetrasperma*. Investigations are now under way to determine the locus of the metabolic block which prevents the consumption of trehalose, thereby restraining the development of the dormant ascospores (*11*).

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9. We are indebted to Venkoba Rao, of the Randall Laboratory, University of Michigan, for having obtained the infrared spectra.
10. The assay for glucose was based upon the "Glucostat" reagent, which was obtained from the Worthington Biochemical Corp., Freehold, N.J.
11. This work was supported by grants from the National Science Foundation (G-5901) and the Phoenix Project of the University of Michigan.
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6 July 1959

Association Affairs

Program Planned for the AAAS Chicago Meeting

Section and society programs in the medical sciences (including dentistry and pharmacy), to be presented at the Chicago meeting, are given here. Programs in mathematics, physics, chemistry, astronomy, geology and geography, the biological sciences, and agriculture have been previously announced.

Medical Sciences

Section N. Four-session symposium: "Aging"; cosponsored by AAAS Sections F–Zoological Sciences, I–Psychology, K–Social and Economic Sciences, and Nd–Dentistry, and the Gerontological Society; 29 and 30 Dec.; arranged by Nathan W. Shock, Baltimore City Hospitals.

Part I: "Implications for Society"; Sidney Spector, Council of State Governments, Chicago, presiding. Papers will be presented on economic aspects (J. W. McConnell, Cornell University); health and medical care (J. T. Freeman, University of Pennsylvania); work and retirement (R. J. Havighurst, University of Chicago); utilization of the aged (Chauncey D. Leake, Ohio State University).

Part II: "Aging in Tissues and Cells"; Kimball Atwood, University of Chicago, presiding. Papers on genetics of aging (Bentley Glass, Johns Hopkins University); aging and development (James Ebert, Carnegie Institute of Embryology, Baltimore); structural changes (Geoffrey Bourne, Emory University); biochemical aspects of aging (Abraham White, Albert Einstein College of Medicine).

Part III: "The Integrated Organism"; Charles B. Huggins, University of Chicago, presiding. Papers on aging of the cardiovascular system (Milton Landowne, Levindale Hebrew Home and Infirmary, Baltimore); the role of the endocrines (Gregory Pincus, Worcester Foundation for Experimental Biology); radiation and aging (Phillip Handler, Duke University); aging and personal relations (Ewald Busse, Duke University).

Part IV: "Theories of Aging"; Allen D. Bass, Vanderbilt University, presiding. Presentation of the 15th Theobald Smith Award, given by Eli Lilly and Company. Vice-presidential address of Section N: "Some of the Facts of Aging," by Nathan W. Shock, Baltimore City Hospitals. Papers on stress theories of aging (Hans Selyé and P. Prioreschi, University of Montreal); dynamic theories of aging (Bernard L. Strehler, Baltimore City Hospitals); behavioral theories of aging (James E. Birren, National Institutes of Health); a philosopher looks at aging (Samuel E. Stumpf, Vanderbilt University).

Alpha Epsilon Delta National Premedical Honor Society. Symposium: "Premedical and Predental Education"; cosponsored by AAAS Sections C–Chemistry, F–Zoological Sciences, N–Medical Sciences, Nd–Dentistry, Beta Beta Beta Biological Society, and the Colleges of Medicine and Dentistry, University of Illinois; 29 Dec.; at the University of Illinois College of Pharmacy Building, Room 56-B, 833 S. Wood Street; arranged by William F. Kellow and Edward J. Forrest, University of Illinois, and Maurice L. Moore, Alpha Epsilon Delta; Lloyd R. Gribble, West Virginia University, presiding. Welcome by Isaac Schour, University of Illinois, and introductory remarks by Lloyd R. Gribble. Papers will be presented on studies of the CAT as a predictor of medical school achievement (Charles F. Schumacher, Association of American Medical Colleges); correlation of the dental aptitude tests with achievement in dental school (Grace Parkin, American Dental Association); tomorrow's doctors need help today (Russell F. Staudacher, Student American Medical Association). Panel discussions will follow on the criteria for admission to dental school and the criteria for admission to medical school.

A luncheon will be held at the Illinois Union Building, 715 S. Wood Street; 29 Dec. Address: "Applicants in Future Years," by Herbert E. Longenecker, vice president in charge of the Chicago Professional Colleges of the University of Illinois.

American Physiological Society. Two-session symposium: "Space Physiology III"; cosponsored by the American Astronautical Society; 28 Dec.; arranged by Fred A. Hitchcock, Ohio State University.

Part I, Fred A. Hitchcock, presiding. Introductory comments: "Space Physiology in the Second Year of the Space Age," by Fred A. Hitchcock. Papers will be presented on protection of humans against effects of high-acceleration stress (James D. Hardy and R. Flanagan Gray, Naval Air Development Center); simulation of space flight on the human centrifuge (Carl C. Clark and Randall W. Chambers, Naval Air Development Center); the selection and training of astronauts for the Mercury project (speaker to be selected, Langley Research Center); physiological aspects of the project Mercury (Stanley White, Langley Research Center).

Part II, Fred A. Hitchcock, presiding. Papers on water recovery systems for space craft (Harold Wallman, General Dynamics Corporation); photosynthetic gas exchangers (Richard Benoit, General Dynamics Corporation); physiological problems on board an atomic submarine (Jack Kinsey, Department of the Navy); the radio telemetry of nerve action potentials (Roger M. Morrell, Montreal Neurological Institute, McGill University).

American Psychiatric Association. Four-session symposium: "Roots of Behavior: Animal Behavior"; cosponsored by AAAS Section I–Psychology, Division of Animal Behavior and Sociobiology of the Ecological Society of America, and the American Society of Zoologists; 28 and 29 Dec.; arranged by Eugene L. Bliss, University of Utah.

Part I; Francis J. Gerty, University of Illinois, presiding. Section I: "The Genetics of Behavior." Papers will be presented on individual differences in behavior and their genetic basis (Jerry Hirsch, Columbia University); the genetic basis of patterns of reproductive behavior in guinea pigs (Robert W. Goy, University of Kansas, and Jacqueline S. Jakway, University of Nebraska); inheritance of behavior in mice (Jan H. Bruell, Western Reserve University); genetic and biological determinants of alcohol preference in mice (David A. Rodgers and Gerald E. McClearn, University of California); genetics of behavior (William C. Dilger, Cornell University). Section II: "Early Experience." Paper on "autonomic reactivity": situational and experiential factors (Ethel Tobach and Theodore C. Schneirla, American Museum of Natural History).

Part II; Martin W. Schein, Pennsylvania State University, presiding. Section II: "Early Experience" continued.

Kodak reports on:

an easy introduction to the chemistry of photography . . . a little something for the taxpayers . . . why it's hard to keep our mind on the store

Book review

You visit a camera shop and browse among the gleaming new wonders of Kodak's Automatic Age in Photography. Possibly you buy one. Then you recall that even in an age of button-pushing, principles underlie buttons. You proceed to the Kodak literature corner and look for the title "Photo Chemistry in Black-and-White and Color Photography."

It may not be there. In that event you show this advertisement to the clerk, thereby convincing him that the book actually exists and that moreover it would mean an easy $1.25 sale for him if he would but order it for you. He, in turn, may convince you that it would be simpler to send $1.35 to Eastman Kodak Company, Sales Service Division, Rochester 4, N. Y., and get it directly by mail. See how it goes.

Acquisition accomplished, comes time to take the measure of the book's content and worth.

The early chapters could well be for the kiddies, the bright ones that start training early for eminence at the Science Fair. That simple is the author's approach to the photographic process and its history, though he writes for an adult who may lack knowledge of the difference between an element and a compound, yet keep up the payments on a split-level by his skill at something like color printing. Even here provocative tidbits sneak in. Do *you* know the difference between chemical and physical development? Between the preparation of a printing-out and a developing-out emulsion? What silver iodide does in an emulsion?

The pace quickens. By page 53, where the chapter "Chemistry of Color Development" begins, the reader is already watching dimethyl-p-phenylenediamine and α-naphthol react with silver bromide to form indophenol blue for the dye image. Soon he is following the reasons for the numerous ingredients of an actual color developer, as we add them one by one.

124 pp., including index. A triumph of exposition, theoretical and practical. You are welcome to quote that.

Microelectronics

Ever hear of the Diamond Ordnance Fuze Laboratories? It's a Department of the Army agency in Washington. To support DOFL, the average citizen shells out the federal tax on, let us say, several gallons of gasoline a year or a little tobacco. Since a fuze is a device which times an explosion to blow up his enemy, he probably wouldn't mind the expense if it were explained to him. But, *mirabile dictu* and happy day, prospects brighten that the piddling investment will pay off beyond the dreams of avarice!

DOFL has spawned "microelectronics," the shrinking of electronic assemblies to 1/100 normal size. DOFL became involved through the proximity fuze program, which requires very small and exceedingly rugged components. We are involved through certain products we make. Microelectronics may be bigger than both of us. It may make possible the placement of electronic devices inside the body, for diagnosis or for replacement or repair of human organs with electronic equivalents. It may permit a new directness in the study of the central nervous system.

The theme of microelectronics is that if you want environment-immune, highly "intelligent" circuitry that can handle problems of logic and fit into a tenth of a cubic inch of space or so, you quit at an early stage of the design thinking of transistors, diodes, capacitors, resistors, and such. Instead you think of the circuit as one or more plates half a millimeter thick and fabricated as intricately as necessary out of various conductive, semi-conductive, and dielectric materials disposed among the three dimensions of each plate.

The technique uses *Kodak High Resolution Plates* on which the geometry of the various sub-circuits is photographed from drawings at great reduction. These then become the masks under which are exposed to ultraviolet light the circuit substrate plates that have been coated with *Kodak Photo Resist*. Where the mask passes u-v, subsequent processing removes the resist and lays open the substrate for either removal of material or insertion of other materials by evaporation, printing, electro-deposition, or chemical deposition.

The next thing to do is to send to Eastman Kodak Company, Special Sensitized Products Division, Rochester 4, N. Y., for a reprint of "The DOFL Microelectronics Program."

Alkylsulfonyl from different viewpoints

A gentleman of Oak Ridge called to our attention a paper (*J. Chem. Soc., 1957*, 2420) which, in the course of examining 29 different alkylsulfonates, reports ethyl methanesulfonate as one of four which effectively inhibit a transplanted rat carcinoma. Previously Haddow and Ross (*Nature, 177*, 995) had reported that this particular compound has the striking feature of greater efficiency when administered orally in aqueous solution (20 mg/rat/day) than by daily injection of the same solution. The sequence of ideas which led Haddow and Ross to this finding is interesting.

The initial idea was that chloroethylamines are potential tumor-growth inhibitors. The second idea was to use the compound 2-chloroethyl methanesulfonate as a reagent for chloroethylating an amino group under mild conditions. The third idea was to run this reaction *in vivo* instead of *in vitro*. This actually worked. 2-Chloroethyl methanesulfonate proved an effective inhibitor in the rat both intraperitonally and orally, and it induced no significant depression of bone marrow.* The fourth idea was to write 2-chloroethyl methanesulfonate as $CH_3SO_2OCH_2$-CH_2X and vary the X from Cl to something else. With X as fluorine, cytotoxic activity persisted. The big surprise must have come with X=H, the unsubstituted ethyl methanesulfonate, the one that works better orally. This shifted the spotlight to the other end of the molecule, where dwells the methanesulfonyl group.

Our heads buzzing, we gave up trying to understand the basic biochemical issues. Our role is that of storekeeper; we must remember that. And what methanesulfonates did we have in the store? We had *n-Butyl Methanesulfonate* (Eastman 4671). (There had been requests for it. We haven't had time to track down why.) We went to work and put *Ethyl Methanesulfonate* on the stockroom shelf as Eastman 7830. Then, as a switcheroo, but with a certain seriousness of purpose, we made *Methyl Ethanesulfonate* (Eastman 7876). Perhaps someone will buy it who wants a deeper understanding of why the interchange of methyl and ethyl groups between the ends of the molecule depresses but does not destroy biological activity.

He will order from Distillation Products Industries, Rochester 3, N. Y. (Division of Eastman Kodak Company). Our Catalog is "Eastman Organic Chemicals, List No. 41." In it are to be found, described and priced, some 3700 highly purified organic chemicals for research.

*Incidentally, it also proved powerfully mutagenic in *Drosophila*, giving an unprecedented high ratio of visibles to lethals, with strongest effects on the youngest germ cells.

Prices quoted are subject to change without notice.

Kodak
TRADE MARK

Papers on maternal behavior and the socialization of kittens (Jay S. Rosenblatt and Theodore C. Schneirla, American Museum of Natural History); imprinting (Eckhard H. Hess, University of Chicago); the psychophysiological effects of infantile stimulation (Seymour Levine, Ohio State University); is early experience different? (John L. Fuller and Marcus B. Waller, Roscoe B. Jackson Memorial Laboratory). Section III: "Instinctual Behavior." Papers on some neurophysiological aspects of insect behavior (Vincent G. Dethier, University of Pennsylvania); the limbic nervous system and sexual behavior (Elliot S. Valenstein, Walter Reed Army Medical Center).

Part III; Eugene L. Bliss, University of Utah, presiding. Section III: "Instinctual Behavior" continued. Papers on the appearance of sexual behavior in platyfish reared under conditions of reduced environmental stimulation (Evelyn Shaw, American Museum of Natural History); a theory of the development of affection and love in primates (Harry F. Harlow, University of Wisconsin); interaction of hormonal and experiential factors in the development of instinctive behavior patterns (Daniel S. Lehrman, Rutgers University); the patterning of sexual behavior by genic, hormonal and experiential factors (William C. Young, University of Kansas); a behavioral approach to the study of hunger and thirst (Jean Mayer and John Falk, Harvard University); aggressive and hostile behavior in animals (John P. Scott, Roscoe B. Jackson Memorial Laboratory).

Part IV; Austin H. Riesen, University of Chicago, presiding. Section III: "Instinctual Behavior" continued. Paper on maternal behavior in the rabbit and a consideration of its endocrine basis (M. X. Zarrow and Victor H. Denenberg, Purdue University; Paul B. Sawin, Roscoe B. Jackson Memorial Laboratory; and Sherman Ross, University of Maryland). Section IV: "Free Ranging Behavior of Primates and Nonprimates." Papers will be presented on "behavioral sinks"—environmental situations which foster the development of behavioral and physiological pathology among socially structured populations of Norway rats (John B. Calhoun, National Institute of Mental Health); the phylogeny of gangs (David E. Davis, Pennsylvania State University); correlations between field and laboratory studies of social development in vertebrate animals (Nicholas E. Collias, University of California at Los Angeles); group composition and behavior correlates in primates (R. Carpenter, Pennsylvania State University); the social behavior of anthropoid primates (Stuart Altmann, Harvard University).

Dentistry

Section Nd. Symposium: "Oral Aspects of Aging"; cosponsored by Section N–Medical Sciences and the Gerontological Society; 28 Dec.; arranged by Frank J. Orland, Zoller Memorial Dental Clinic, University of Chicago, who will preside. Papers will be presented on growth and aging of the face (Samuel Pruzansky, Center for Handicapped Children, University of Illinois); the aging of tissues of the oral cavity (Earl O. Butcher and Jules Klingsberg, New York University); histochemical and histological age changes in oral subepithelial connective tissue (John R. Ring, Washington University); aging pattern in teeth of different population groups (Albert A. Dahlberg, University of Chicago); structural age changes in human teeth (John Nalbandian and Reidar F. Sognnaes, Harvard School of Dental Medicine); discussion of selected areas for investigation in oral research (David Weisberger, Harvard School of Dental Medicine and Massachusetts General Hospital).

Symposium: "American Dentistry at the Centennial Crossroad"; cosponsored by the American Dental Association,

American Association of Dental Schools, International Association for Dental Research (North American Division), American College of Dentists, and the American Academy of the History of Dentistry; 29 Dec.; arranged by Frank J. Orland, Zoller Memorial Dental Clinic, University of Chicago, who will preside. Papers will be presented on dental materials during the last hundred years: a brief résumé (George C. Paffenbarger, National Bureau of Standards); the use of epidemiology in dental research (H. Trendley Dean, National Institute of Dental Research); development of dental disease concepts and research information (Robert M. Stephan, National Institute of Dental Research); educational progress during the last century (Shailer Petersen, American Dental Association); review of journalism in the dental field (Lon W. Morrey, editor of the *Journal of the American Dental Association*); philosophical problems of dentistry in its 100th year (Byron S. Hollinshead, American Council on Education).

Pharmacy

Section Np. There will be four sessions of contributed papers; 28 and 29 Dec. Session I; arranged by John E. Christian, Purdue University, with George L. Webster, University of Illinois, presiding. Session II; arranged by John E. Christian with John Autian, University of Michigan, presiding. Session III; Hospital Pharmacy, arranged by George F. Archambault, Department of Health, Education, and Welfare, and Joseph A. Oddis, American Hospital Association, with Joseph A. Oddis presiding. Session IV; Hospital Pharmacy, arranged by George F. Archambault and Joseph A. Oddis, with George F. Archambault presiding.

Vice-presidential address by Glenn L. Jenkins, Purdue University; 29 Dec.; American Hospital Association Headquarters Building, 840 North Lake Shore Drive.

Two-session symposium: "The Scientist's Part in Protection of the Public"; 30 Dec.; arranged by John E. Christian, Purdue University. Part I: "Food, Drug, Cosmetic, and Hazardous Chemical Problems"; Joseph V. Swintosky, Smith, Kline, and French Laboratories, presiding. Papers will be presented on the labeling of hazardous chemicals—a help or a hindrance (Bernard E. Conley, American Medical Association); pharmaceutical ingredients legislation, the problems and approaches to solving them (William F. Bousquet, Purdue University); the role of the cosmetic scientist in protecting the public health (Raymond E. Reed, The Toni Company); the applications of radioisotope tracer techniques to

studying the food additive problem (John H. Rust, University of Chicago); problems in evaluating the safety of international food additives (O. Garth Fitzhugh, Department of Health, Education, and Welfare).

Part II: "Food Additive Legislation"; Glenn L. Jenkins, Purdue University, presiding. Papers on problems in evaluating the safety of unintentional food additives (A. J. Lehman, Department of Health, Education, and Welfare); scientific judgment in law and regulation (Edward J. Matson, Abbott Laboratories); the role of the scientific expert under recent food laws (Bernard L. Oser, Food and Drug Research Laboratories, Inc.). A discussion session will follow the symposium.

All the sessions of Section Np are cosponsored by the American Pharmaceutical Association Scientific Section, the American Association of Colleges of Pharmacy, American Society of Hospital Pharmacists, American College of Apothecaries, and the National Association of Boards of Pharmacy.

Forthcoming Events

December

5–10. American Acad. of Dermatology and Syphilology, Chicago, Ill. (R. R. Kierland, First National Bank Bldg., Rochester, Minn.)

6. American Acad. of Dental Medicine, mid-annual, New York, N.Y. (A. J. Cannistraci, 2152 Muliner Ave., New York 62.)

6–10. American Inst. of Chemical Engineers, annual, San Francisco, Calif. (F. J. Van Antwerpen, AICE, 25 W. 45 St., New York 36.)

7–12. Algology, UNESCO symp., New Delhi, India. (J. P. Correa, South Asia Cooperation Office, 21, Curzon Rd., New Delhi, India.)

8–10. Application of Electrical Insulation, 2nd natl. conf., Washington, D.C.) (N. S. Hibshman, AIEE, 33 W. 39 St., New York 18.)

9–15. American Acad. of Optometry, Chicago, Ill. (C. C. Koch, 1506–1508 Foshay Tower, Minneapolis 2, Minn.)

11–12. American Rheumatism Assoc., Detroit, Mich. (F. E. Demartini, Presbyterian Hospital, 622 W. 168 St., New York 32.)

11–12. Association for Research in Nervous and Mental Disease, annual, New York, N.Y. (R. J. Masselink, 700 W. 168 St., New York 32.)

11–12. Oklahoma Acad. of Science, Weatherford. (R. Kelting, Life Sciences Department, Univ. of Tulsa, Tulsa, Okla.)

11–12. Salt and Water Metabolism, symp., New York, N.Y. (A. P. Fishman, New York Heart Assoc., 10 Columbus Circle, New York 19.)

11–12. Texas Acad. of Science, Austin. (L. Kennamer, Dept. of Geography, Univ. of Texas, Austin 12.)

16–18. American Soc. of Agricultural

Engineers, Chicago, Ill. (J. L. Butt, P.O. Box 229, St. Joseph, Mich.)

25–27. Indian Mathematical Soc., 25th conf., Allahabad, India. (B. N. Prasad, Allahabad Univ., Lakshmi Niwas, George Town, Allahabad 2.)

26–30. American Assoc. for the Advancement of Science, annual, Chicago, Ill. (R. L. Taylor, AAAS, 1515 Massachusetts Ave., NW, Washington 5.)

The following 46 meetings are being held in conjunction with the AAAS annual meeting.

AAAS Committee on Science and the Promotion of Human Welfare (B. Commoner, School of Botany, Washington Univ., St. Louis 5, Mo.). 27 Dec.

AAAS Cooperative Committee on the Teaching of Science and Mathematics (Brother G. Nicholas, Univ. of Notre Dame, Notre Dame, Ind.). 27 Dec.

Academy Conference (A. M. Winchester, Stetson Univ., De Land, Fla.). 27–28 Dec.

Alpha Epsilon Delta (M. L. Moore, 7 Brookside Circle, Bronxville, N.Y.). 29 Dec.

American Assoc. of Clinical Chemists (A. Dubin, Director of Biochemistry, Cook County Hospital, Chicago 12, Ill.). 26–27 Dec.

American Geophysical Union (W. C. Krumbein, Dept. of Geology, Northwestern Univ., Evanston, Ill.). 28 Dec.

American Meteorological Soc. (K. Spengler, 3 Joy St., Boston, Mass.).

American Nature Study Soc. (E. L. Will, State Univ. Teachers College, Oneonta, N.Y.). 26–30 Dec.

American Physiological Assoc. (F. A. Hitchcock, Ohio State Univ., Columbus). 28 Dec.

American Political Science Assoc. (J. Robinson, Dept. of Political Science, Northwestern Univ., Evanston, Ill.). 28 Dec.

American Psychiatric Assoc. (E. L. Bliss, General Hospital, Salt Lake City, Utah). 28–29 Dec.

American Soc. of Criminology (D. E. J. MacNamara, New York Inst. of Criminology, Inc., New York 36). 28–29 Dec.

American Soc. of Naturalists (A. D. Hasler, Dept. of Zoology, Univ. of Wisconsin, Madison). 27–28 Dec.

American Soc. of Plant Taxonomists (L. R. Heckard, Dept. of Botany, Univ. of Illinois, Urbana). 28–30 Dec.

American Sociological Soc. (J. S. Coleman, Dept. of Sociology, Univ. of Chicago, Chicago 37, Ill.). 28–29 Dec.

American Statistical Assoc. (R. F. Winch, Dept. of Sociology, Northwestern Univ., Evanston, Ill.). 29–30 Dec.

Association of American Geographers (A. Cutshall, Univ. of Illinois, Navy Pier, Chicago 11). 29 Dec.

Association for Computing Machinery (W. F. Cahill, Goddard Space Flight Center, Silver Spring, Md.). 29 Dec.

Astronomical League (E. Halbach, 2971 S. 52 St., Milwaukee 19, Wisc.). 26 Dec.

Beta Beta Beta (Mrs. F. G. Brooks, P.O. Box 515, Ansonia Station, New York 23). 27–28 Dec.

Chicago Acad. of Sciences (R. A. Edgren, Chicago Academy of Sciences, 2001 North Clark St., Chicago 14, Ill.) 29-30 Dec.

Conference on Scientific Communications (G. L. Seielstad, Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md.). 28–29 Dec.

Conference on Scientific Manpower (T. J. Mills, National Science Foundation, Washington 25). 28 Dec.

Ecological Soc. of America (W. C. Ashby, Dept. of Botany, Univ. of Chicago, Chicago 37, Ill.). 28–30 Dec.

Honor Soc. of Phi Kappa Phi (L. R. Guild, 634 S. Western Ave., Los Angeles 5, Calif.). 30–31 Dec.

Illinois Geographical Soc. (Miss M. Grant, Morton Junior College, Cicero, Ill.). 28 Dec.

Institute of Management Sciences (M. M. Flood, College of Engineering, Univ. of Michigan, Ann Arbor). 29 Dec.

Metric Assoc. (J. T. Johnson, Ravenswood YMCA, 1725 Wilson Ave., Chicago 40, Ill.).

Mycological Soc. of America (D. P. Rogers, Dept. of Botany, Univ. of Illinois, Urbana).

National Assoc. of Biology Teachers (H. E. Weaver, 202 Men's Old Gym, Univ. of Illinois. Urbana). 26–30 Dec.

National Acad. of Economics and Po-

litical Science (J. Rothrock, Pan American Union, Washington 6). 29 Dec.

National Assoc. for Research in Science Teaching (J. C. Mayfield, Univ. of Chicago, Chicago 37, Ill.). 26–30 Dec.

National Assoc. of Science Writers (P. Fraley, Evening Bulletin, Philadelphia, Pa.). 27 Dec.

National Geographic Soc. (W. R. Gray, NGS, 16 and M Sts., NW, Washington 6). 30 Dec.

National Science Teachers Assoc. (R. H. Carleton, NSTA, 1201 16 St., NW, Washington, D.C.). 26–30 Dec.

National Soc. for Medical Research (R. A. Rohweder, NSMR, 920 S. Michigan Blvd., Chicago 5, Ill.). 29 Dec.

National Speleological Soc. (T. C. Barr, Jr., Tennessee Polytechnic Inst., Cookeville, Tenn.). 28 Dec.

Philosophy of Science Assoc. (W. A. R. Ley, Roosevelt College, Chicago, Ill.). 28 Dec.

Scientific Research Soc. of America (D. B. Prentice, 56 Hillhouse Ave., New Haven 11, Conn.). 29 Dec.

Sigma Delta Epsilon (Miss E. S. Anderson, Stratford Hotel, 25 E St., NW, Washington, D.C.). 26–30 Dec.

Society for General Systems Research (R. L. Meier, Mental Health Research Institute, Univ. of Michigan, Ann Arbor).

Society for the History of Technology (M. Kronzberg, Dept. of History, Case Inst. of Technology, Cleveland, Ohio).

Society of the Sigma Xi (T. T. Holme, 56 Hillhouse Ave., New Haven 11, Conn.). 29 Dec.

Society of Systematic Zoology (R. E. Blackwelder, Southern Illinois Univ., Carbondale). 26–30 Dec.

Tau Beta Pi Assoc. (R. H. Nagel, Univ. of Tennessee, Knoxville). 27 Dec.

United Chapters of Phi Beta Kappa (C. Billman, 1811 Q St., NW, Washington, D.C.). 29 Dec.

27–30. American Anthropological Assoc., Mexico City. (W. S. Godfrey, Jr., Logan Museum, Beloit College, Beloit, Wisc.)

27–30. American Astronomical Soc., Cleveland, Ohio. (J. A. Hynek, Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge 38, Mass.)

27–30. American Folklore Soc., Mexico City. (MacE. Leach, 110 Bennett Hall, Univ. of Pennsylvania, Philadelphia 4.)

27–30. American Statistical Assoc., Washington, D.C. (D. C. Riley, 1757 K St., NW, Washington 6.)

27–30. Institute of Mathematical Statistics (weather control), Washington, D.C. (J. Neyman, Statistical Lab., Univ. of California, Berkeley 4.)

28–29. American Chemical Soc. (Div. of Industrial and Engineering Chemistry), symp., Baltimore, Md. (M. A. H. Emery, ACS, 18 and K Sts., NW, Washington D.C.)

28–29. Industrial Relations Research Assoc., Washington, D.C. (E. Young, Sterling Hall, Univ. of Wisconsin, Madison.

28–29 Mechanism of Interfacial Reaction, American Chemical Soc., annual symp, Baltimore, Md. (H. E. Hoelscher, Chemical Engineering Dept., Johns Hopkins Univ., Baltimore, Md.)

28–29. Lepidopterists' Soc., 10th annual,

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Ann Arbor, Mich. (E. G. Voss or W. H. Wagner, Dept. of Botany, Univ. of Michigan, Ann Arbor.)

28–29. Northwest Scientific Assoc., Spokane, Wash. (W. B. Merriam, Dept. of Geography, State College of Washington, Pullman.)

28–30. American Economic Assoc., Washington, D.C. (J. W. Bell, Northwestern Univ., 629 Noyes St., Evanston, Ill.)

28–30. American Philosophical Assoc. (eastern div.), New York, N.Y. (L. Garvin, Dept. of Philosophy, Univ of Maryland, College Park.)

28–30. American Physical Soc., Pasadena, Calif. (K. Darrow, APS, Columbia Univ., 116 St. and Broadway, New York, N.Y.)

28–30. Econometric Soc., Washington, D.C. (R. Ruggles, Dept. of Economics, Yale Univ., New Haven, Conn.)

28–30. Western Soc. of Naturalists, Los Angeles, Calif. (Y. U. Amrein, Dept. of Zoology, Pomona College, Claremont, Calif.)

28–31. Phi Delta Kappa, Columbia, Mo. (A. G. Clark, 316 Dalzell Ave., Ben Avon, Pittsburgh 2, Pa.)

28–16. Bahamas Surgical Conf., Nassau. (B. L. Frank, P.O. Box 4037, Fort Lauderdale, Fla.)

January

1–5. Electrochemical Soc., Chicago, Ill. (Electrochemical Soc., Inc., 216 W. 102 St., New York 25.)

1–5. Institute of Geographers, annual conf., Southampton, England. (A. E. Smailes, Queen Mary College, Univ. of London, Mile End Rd., London, E.1.)

3–9. Indian Science Cong. Assoc., 4th, Bombay. (B. W. Prasad, ISCA, Lakshmi Niwas, Georgetown, Allahabad 2, India.)

5–7. Recent Mechanical Engineering Developments in Automatic Control, symp., London, England. (Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1.)

6–8. Northeastern Weed Control Conf., 14th annual, New York, N.Y. (M. G. Wiltse, Chairman, Public Relations Committee, Dow Chemical Co., 916 Shoreham Bldg., 15 and H Sts., NW, Washington 5.)

7–10. Radioactive Isotopes, 4th intern. symp., Bad Gastein, Austria. (R. Hofer, Isotopen-Laboratorium, II. Medizenische Universitäts Klinik, 13, Garnisongasse, Vienna 9, Austria.)

8–11. Sanitary Engineering Conf., ASCE, Cincinnati, Ohio. (E. S. Kirkpatrick, ASCE, 33 W. 39 St., New York 18.)

11–13. American Acad. of Allergy, Hollywood-by-the-Sea, Fla. (J. O. Kelley, 756 N. Milwaukee St., Milwaukee 2, Wisc.)

11–13. Arctic Geology, 1st intern. symp., Calgary, Alberta, Canada. (D. W. R. Wilson, Arctic Symposium Committee, P.O. Box 100, Calgary, Alberta, Canada.)

11–13. Reliability and Quality Control, natl. symp., Washington, D.C. (N. S. Hibshman, AIEE, 33 W. 39 St., New York 18.)

11–15. Society of Automotive Engineers, annual, Detroit, Mich. (R. W. Crory, Meetings Operation Dept., SAE, 485 Lexington Ave., New York 17.)

11–25. Effects of Atomic Radiation, New York, N.Y. (R. Appleyard, Scientific

Committee on the Effects of Radiation, United Nations, New York 17.)

12–15. Society of Plastics Engineers, 16th annual conf., Chicago, Ill. (T. A. Bissell, SPE, 65 Prospect St., Stamford, Conn.)

14–18. American Inst. of Mining, Metallurgical, and Petroleum Engineers, annual, New York, N.Y. (E. O. Kirkendall, AIMMPE, 29 W. 39 St., New York 18.)

17–30. Bahamas Medical Serendipity Conf., 2nd, Nassau. (B. L. Frank, P.O. Box 4037, Fort Lauderdale, Fla.)

18–21. American Astronautical Soc., 6th annual, New York, N.Y. (A. P. Mayernik, AAS, 6708 53 Rd., Maspeth 78, N.Y.)

19–21. American Meteorological Soc., 40th annual, Boston, Mass. (K. C. Spengler, 3 Joy St., Boston.)

19–21. Congenital Malformations, CIBA symp. (by invitation only), London, England. (G. E. W. Wolstenholme, 41 Portland Pl., London, W.1.)

21–23. American College of Surgeons, Louisville, Ky. (H. P. Saunders, 40 E. Erie St., Chicago 11, Ill.)

23–28. American Acad. of Orthopedic Surgeons, Chicago, Ill. (J. K. Hart, 116 S. Michigan, Chicago 3.)

24–29. American Rocket Soc., Princeton, N.J. (J. J. Harford, ARS, 500 Fifth Ave., New York 36.)

25–28. Institute of the Aeronautical Sciences, 28th annual, New York, N.Y. (IAS, 2 E. 64 St., New York 21.)

25–28. Plant Maintenance and Engineering Show, Philadelphia, Pa. (R. S. Wolcott, Clapp & Poliak, 341 Madison Ave., New York 17.)

25–29. Stress Measurement Methods, symp., Tempe, Ariz. (P. K. Stein, Strain Gage Readings, 5602 East Monte Rosa, Phoenix, Ariz.)

27–28. College-Industry Conf., Amer. Soc. for Engineering Education, St. Louis, Mo. (W. L. Collins, ASED, Univ. of Illinois Urbana.)

27–28. Group Therapist, 4th annual, AGPA, New York, N.Y. (American Group Psychotherapy Assoc., Inc., 1790 Broadway, New York 19.)

27–29. American Mathematical Soc., 66th annual, Chicago, Ill. (J. W. Green, Univ. of California, Los Angeles 34.)

27–30. American Physical Soc., annual, New York, N.Y. (K. Darrow, APS, Columbia Univ., 116 St. and Broadway, New York.)

28–30. Mathematical Assn. of America, 43rd annual, Chicago, Ill. (H. M. Gehman, Univ. of Buffalo, Buffalo 14, N.Y.)

28–30. Western Soc. for Clinical Research, 13th annual, Carmel-by-the-Sea, Calif. (W. N. Valentine, Western Soc. for Clinical Research, Univ. of California Medical Center, Dept. of Medicine, Los Angeles 24.)

29–30. American Group Psychotherapy Assoc., Inc., 17th annual conf., New York, N.Y. (American Group Psychotherapy Assoc., Inc., 1790 Broadway, New York 19.)

31–5. American Inst. of Electrical Engineers, New York, N.Y. (N. S. Hibshman, AIEE, 33 W. 39 St., New York 18.)

31–7. Pan American Cong. of Ophthalmology, 6th, Caracas, Venezuela. (J. W. McKinney, 921 Exchange Bldg., Memphis, Tenn.)

New Products

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Neither Science *nor the writer assumes responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed is included in the post card insert.*

■ NULL DETECTOR designed for use with bridges is a tuned detector covering the frequency range 20 cy to 200 kcy/sec. Input impedance is 1 megohm shunted by 100 $\mu\mu$f. Indication is provided by a 2-in. cathode-ray tube with deflection of 0.25 in. for 10-μv input. Discrimination against the second harmonic is 40 db. (Boonton Electronics Corp., Dept. 189)

■ CENTRIFUGE for testing has two outboard rotating tables mounted on the boom. One table, electrically driven, may be rotated at 0 to 1800 rev/min to provide sinusoidally varying fields. The other table, electropneumatically operated, permits $\pm$90 deg rotation in milliseconds to produce high-acceleration ramp functions. Speed of the main arm is controlled through an electrohydraulic servo system. (Genisco, Dept. 191)

■ SHAFT-ANGLE ENCODER provides full-scale encoding of 1000 revolutions with 1000 code positions per revolution. A first 1000-position encoder is geared 100-to-1 to a 100-position encoder, and the latter is geared to a 10-position encoder. The device will operate at temperatures from 32° to 150°F and in vibration environments of 8 *g* at 2000 cy/sec. (Datex Corp., Dept. 192)

■ METERING PUMP is adjustable from 0 to 6.44 cm^3 per stroke. Pumping pressure can be as much as 354 lb/in.^{2} and is determined by the operating air pressure and the bore of the air cylinder. The pump is actuated by a solenoid. (Airmatic Valve, Dept. 197)

■ SHOCK INDICATORS indicate shock experienced by delicate equipment in shipment. The units indicate visibly that a predetermined permissible level has been exceeded. One- or two-plane or spherical sensitivity can be provided in ranges from 5 to 75 *g* with $\pm$5 percent accuracy. The devices are reusable and resettable. (Inertia Switch, Dept. 198)

■ TEMPERATURE RECORDER measures and records up to 75 iron-constantan thermocouple inputs. The system consists of an input scanner, self-balancing potentiometer, shaft encoders, encoder selector, control chassis, programmer, digital clock, and electric typewriter. Temperature ranges are −30° to 120°, 250° to 600°, and 0° to 1200°F. Scan-

ning rate is 3 sec per data point. Accuracy is said to be $\pm 1°F$ in the lower ranges and $\pm 5°F$ in the highest range. Read-out format is two decimal digits of identification and four decimal digits of temperature. (Datex Corp., Dept. 200)

■ DROP COUNTER, for fraction collection, manufactured by LKB-Produkter of Sweden, uses a photoelectric cell to detect falling drops. Fraction sizes from 0.1 to 10 ml and of 4, 8, 16, 32, 64, and 128 drops per fraction can be selected. (Ivan Sorvall, Dept. 205)

■ MAGNETORESISTOR is a semiconductor in which electrical resistance is a function of magnetic field, featuring a 10-to-1 change in resistance with an applied field of 10 kgauss. The device utilizes indium antimonide. Typical specifications are: Resistance, 1 ohm ± 20 percent; power rating, 0.25 watt; temperature range, 0° to 100°C; dimensions, 5/8 by 1/2 by 0.03 in. (Ohio Semiconductors, Inc., Dept. 207)

■ MULTIPLIER PHOTOTUBES for measurement of very low levels of radioactivity are fabricated of selected materials that contain very few radioactive contaminants. The tubes have quartz face plates. A tube 3 in. in diameter has been announced. (Allen B. DuMont Laboratories, Dept. 199)

■ ANALOG MULTIPLIER is said to provide four-quadrant multiplication with dynamic accuracy ± 0.05 percent of full scale at 500 cy/sec. In the device, one variable is used to control frequency deviation about the 1.5 Mcy/sec. reference frequency, while the other variable controls the amplitude of the carrier. Multipliers may be used as dividers by manipulation of a single relay. An output selection circuit scales output as $xx/100$, $xy/10$ or xy. Noise level is less than 30 mv, drift less than 50 mv in 8 hr. Input impedance is greater than 1 Mohm; output impedance is approximately 0.05 ohm. (Computer Systems, Dept. 206)

■ RECORDER for strain-versus-load data is a 24-channel instrument with one, two or four active bridge arms. Individual graphs and three zero positions are provided for each channel. Either 4 or 24 gage-factor controls and range selectors are furnished. Adjustment of zero and gage factor is automatic. (Gilmore Industries, Dept. 201)

■ VOLTMETER of potentiometer type measures from 0 to 10 volts d-c on either polarity with accuracy said to be ± 0.025 percent plus 3 μv in portable operation. Read-out is provided by six decade switch dials with resolution of ± 10 μv and by a panel galvanometer for fractional microvolt resolution. Stability of reference supply is said to be ± 0.005 percent for line variation from 107 to 127 volts. (Siegler Corp., Dept. 202)

■ ULTRASONIC WELDER for small and delicate assemblies accomplishes welding without melting and without passage of electric current through parts to be joined. Power input is 100 watts. (Aeroprojects, Inc., Dept. 208)

■ IMAGE AMPLIFIER uses television techniques to show 11-by-11-in. fluoroscopic images on television-type monitors. With this equipment, a radiation rate of 2 mr is said to be adequate for diagnostic viewing of a thorax. Accessory equipment to be available in the future will permit holding of an image without continued irradiation. (Marconi Instruments, Ltd., Dept. 209)

■ SPECTRUM ANALYZER for the range 50 cy to 100 kcy/sec applies any 2.5 kcy/sec input band simultaneously to 100 32-cy/sec band-pass filters and scans the filter outputs in sequence at a rate of 3450 per minute. Resolution

is 75 cy/sec with dynamic resolving range 35 to 40 db. Variations in amplitude response are within ±3 db. Another model is available with resolution 250 cy/sec. (Raytheon Co., Dept. 213)

■ THERMISTOR SLIDE RULE is entered with thermistor shape desired and resistance at 25°C and reads resistance at all temperature points of the thermistor curve. Dimensions, dissipation and time constants, and maximum temperature limits are also given for several hundred thermistors. (Fenwal Electronics, Dept. 214)

■ RESISTANCE BRIDGE uses an electronic null indicator to permit rapid inspection of resistors on an accept-reject basis with accuracy said to be ± 0.2 percent. The range 10 ohm to 11,111,100 ohm is covered in 10-ohm steps with tolerance adjustable between ±1 and ±20 percent. (Shallcross Manufacturing Co., Dept. 217)

■ KERR-CELL SHUTTER consists of a Kerr cell, spark gap, pulse transformer, high-voltage power supply, and variable-delay trigger generator. Exposure time is 30 mμsec. Cell aperture is 40 by 40 mm, 20 mm thick, and transmission ratio is 10^5. Trigger may be manual, contact closure, or step voltage, with delay 1 to 125 μsec. (Oltronix Inc., Dept. 211)

■ VACUUM PUMP depends on the reaction between gases and titanium vapor to produce vacuums in the range 0.05 to 1×10^{-9} mm-Hg. The device consists of a stainless-steel cartridge 7 5/16 in. long and approximately ½ in. diameter. A source of 60-amp, 3-volt power is used to evaporate the titanium. Pumping speed is approximately 5 liter/sec; filament life is approximately 500, 1-min evaporations at 1 μ-Hg or lower. Filaments are replaceable. (National Research Corp. Dept. 215)

■ COOLING DEVICE for infrared detectors operates by expanding 300 lb/in.² helium in a ¼-in. diameter cylinder 2-in. long. The temperature of the infrared cell is reduced to 60°K. Weight of the cooler is 8 oz. (Arthur D. Little, Inc., Dept. 212)

■ NOISE SOURCE consists of a "white-noise" generator that can be set for constant energy per cycle or per octave, feeding through a driver amplifier into eight attenuators, each in turn connected to an octave-band filter. Spectrum coverage is 20 to 9600 cy/sec with provision for a ninth band 9600 to 19,200 cy/sec. Each band can be adjusted to simulate an environmental noise spectrum. (Allison Laboratories, Inc., Dept. 216)

■ LEVEL-SENSING POTENTIOMETER is an air-bubble type in which the fluid is an electrolyte. Electrodes are arranged in the curved glass tube so that resistances between two end electrodes and a center electrode are equal when the unit is horizontal. When the instrument is used as half of a 1000-ohm bridge with 12 volts applied, tilting of 0.25 deg produces an output of 4 volts. Saturation is reached at approximately ¾ deg. (Hamlin, Inc., Dept. 220)

■ POWER AMPLIFIER for particle-accelerator drive applications is tunable from 195 to 205 Mcy/sec, producing 1-to-20 kw peak pulse output with input pulse power of 50 watts. Pulse repetition rate is 5 to 60 per second. Pulse length is variable from 150 to 400 μsec, with rise time 5 μsec from 10 to 90 percent and droop less than 5 percent. Remote console operation can be arranged. (Levinthal Electronic Products, Dept. 222)

■ TRANSFER-FUNCTION BRIDGE measures input and output impedance and admittance of two-, three-, and four-terminal devices and networks over the

frequency range 25 to 1500 Mcy/sec. Standard mounts are available for measurements on transistors and for common-cathode measurements on seven-pin miniature tubes. The bride is passive; stability of calibration is dependent only on physical dimensions. Measurement ranges are: voltage and current ratios, 0 to 20; transimpedance, 0 to 1500 ohm; transadmittance, 0 to 600 mho; impedance, 0 to 1000 ohm; admittance, 0 to 400 mho. (General Radio Co., Dept. 221)

■ PHYSIOLOGICAL DATA TELEMETERING SYSTEM is a 20-lb. electronic package that measures blood pressure, heart rate, heart sounds, respiration rate and depth, skin temperature, and galvanic skin resistance. Intended for space research, the equipment is designed to operate in extreme environmental temperatures and under accelerations of several grav. (Gulton Industries, Inc., Dept. 219)

■ SUBCARRIER OSCILLATOR CALIBRATOR for FM telemetering calibration in field or laboratory is said to maintain accuracy of ±¼ percent bandwidth under all conditions of use. The panel meter reads directly in percentage bandwidth; meters for remote indication are available. (Wayne D. Patterson, Inc., Dept. 218)

JOSHUA STERN

National Bureau of Standards, Washington, D.C.

Letters

(Continued from page 1302)

Sulloway's, which purports to set out Catholic doctrine on some subject, is to determine whether the Catholic Church has actually taken a doctrinal stand in the matter. Unless she has, there *is* no "position of the Catholic Church," and writers may, and almost always do, argue pro and con.

The Church is considered to have taken a doctrinal stand in a matter when she has (i) made an infallible pronouncement by the head of the Church; (ii) defined by an Ecumenical Council; (iii) authoritatively proposed some creed, formula of belief, or matter of moral behavior.

Consider two examples, the first being the question of the geocentric and heliocentric theories of planetary motion. When the latter was first proposed in university circles by a Catholic, Copernicus, some Catholic writers were for it, but the great majority were against it. The Church, however, did not then, and never has since, taken a *doctrinal* stand in the matter. The fact that "Catholic authors" adopted this or that position does not have anything to do with the question.

For many centuries the majority of "Catholic authors" took the position that at the end of her earthly career the mother of Christ was taken up body and soul into heaven. There were, however, some "Catholic authors" who thought her body was not assumed. After 1 November 1950 the matter was closed by a formal doctrinal statement by the head of the church.

In the case of birth control the Church never has taken a doctrinal stand that "separation of intercourse and parenthood" is wrong. If she had, she could never have allowed marriage between those who are sterile, nor between those who, because of advanced age, have passed the time when conception can naturally take place. However, the legitimacy of the union and the rights of the partners to use their marital privileges have been recognized in these cases for centuries. Unfortunately, since Davis was unaware of these points, he was unable to point out that a major part of Sulloway's thesis is irrelevant.

The second question that must be considered concerns the nature of the Catholic Church.

It is certainly understandable that Sulloway, believing the Church both inconsistent and in error, would hope it would change its mind on (what he thinks is) its doctrinal stand. Your reviewer is apparently unaware that an *essential* claim of the Catholic Church is that when it *does* take a definite doc-

trinal stand it cannot be in error. This is because the Church believes it was founded by God and guaranteed by him against error in "faith and morals." Over a period of 20 centuries the Church has never made an essential change in any of its doctrines.

Two other points should be mentioned in connection with the review.

1) Davis believes that the method of birth control does not determine the morality of marital intercourse as long as the married couple "intends in good faith to have children and does have them." The Catholic Church, on the other hand, believes that the end does not justify the means, and that the use of bad means for a good end makes the act morally bad. While the end, limitation of the number of children, may be good in some cases, the means, artificial birth control, are always bad.

2) Davis does not make a proper distinction between the Church's philosophical and theological position and the *tactics* that may be employed by Catholics in certain instances. The *laws* against contraceptives were placed on the statute books of Massachusetts and Connecticut by Protestants in the latter part of the 19th century. It is only natural that, in opposing Margaret Sanger and her coworkers of 1914, Catholics should make use of existing laws. The "first line of defense" against a fire is an existing firehose.

Finally, I hope that in the future, when books of this type are reviewed, the editors of *Science* will insist on the same objectivity in presentation of the position of the Catholic Church that they would on any strictly scientific matter.

J. KENNETH O'LOANE
331 Seneca Parkway, Rochester, New York

Moon Illusion and Age

Leibowitz and Hartman in their report "Magnitude of the moon illusion as a function of the age of the observer" [*Science* **130**, 569 (1959)] interpret the moon illusion "as resulting from a normal developmental process, namely the dependence of the magnitude of the size constancy correction on experience." This conclusion is not in conflict with the result of their outdoor experiment, where presumably there were objects of common experience in the horizontal plane which could provide the subjects with size standards and with landmarks for parallax distance determination. However, it is difficult on the basis of this "experience" theory to see how the same results could be obtained in a darkened theater. If the theater is darkened to the extent that

no common objects remain in view, then accommodation and convergence will provide the only cues to the distance of the disks. (I assume this was the reason for conducting the experiment in the dark.) In the darkened theater, then, there remain but two variables: the position of the head relative to the body, and the angular aspect of the otolithic organs. While it seems reasonable that these might be related to perceived size, it is not clear why the postural experience of children and adults should lead to the results obtained.

Furthermore, I would like to point out one assumption underlying the mathematical sign of the correction. The authors state that, for near objects, "for a given retinal image size, perceived size is proportional to distance. However, as the observation distance is increased, this correction is no longer complete, and especially so the younger the subject." This implies that the correction is a magnification which increases with increasing distance. I note that, just as logically, the correction might be a diminution which increases in absolute value with decreasing distance. This distinction bears on the following point. That the illusion is stronger for the children than the adults may be explained in two ways. Either the children misjudge the distance of the disk when it is overhead (believing it to be closer than the adults believe it to be) and "correct" just as an adult would for an object at that distance, or the children judge the distance of the overhead moon as an adult would but apply a correction different from that an adult would apply. (I take the first quotation in this letter to indicate that the authors favor the latter explanation.) Now here the sign of the correction assumes importance. If the correction is a magnification, in the above sense, then the children are not correcting enough, and the correction will increase with age. But, on the other hand, if the correction is a diminution, then the children are overcorrecting, and the correction will decrease with age.

HOWARD C. HOWLAND

Department of Zoology, University of Pennsylvania, Philadelphia

We agree with Howland with respect to the possible importance of postural and vestibular cues as factors influencing perceived size. It seems reasonable to assume, on the basis of developmental studies, that children may be more dependent on stimulation from proprioceptors than adults. Whether this is also true for perceived size is currently being investigated in this laboratory.

While it is logically correct to consider that the size constancy "correc-

tion" might be a diminution which increases in absolute value with decreasing distance, such an assumption would not be preferred, in view of the experimental data relating size matches to the age of the observer. Children and adults produce the same matches—that is, make a correction for distance of the same magnitude—for close observation distances. It is only by increasing distance that differences are obtained, as manifested by the more rapid falling off of the tendency toward constancy for the younger as compared to the older subjects. We have interpreted these data to imply the following relationship: the younger the subject and the greater the distance of observation, the smaller the magnitude of the correction. We suggested also that experience plays a role in this correction, although we are not certain whether it is mediated by visual or proprioceptive cues. The data obtained in the dark room, which presented some visual cues due to scattered light from the projector beams, do not permit us to make a decision at this time.

The suggestion that one investigate the role of perceived distance, with perceived size considered as a secondary effect, is both logical and tempting. Experimentally, however, it has proved to be relatively easy to obtain reliable measures of perceived size but extremely difficult to measure perceived distance, especially with children. For this reason, we prefer to avoid speculating as to whether perceived size or perceived distance is the more basic variable, and to emphasize the dependent variable of matched size, which can be assessed experimentally. We know for certain that as physical distance is increased, size matches become less veridical, but we are not able, due to methodological limitations, to determine whether these data result from a failure of perceived size or of perceived distance.

H. LEIBOWITZ
T. HARTMAN
University of Wisconsin, Madison

Correlation

The recent Stetten and Hearon report, "Intellectual level measured by Army Classification Battery and serum uric acid concentration" [*Science* **129**, 1737 (1959)], gives a coefficient of correlation of +.0759, which the authors in effect say is statistically significant. From this result the authors conclude that "a low level of positive correlation . . . does indeed exist between the score attained in the ACB test and the level of uric acid in blood serum in the population studied."

Leaving aside the unusual device of reporting an estimate like this to four decimal places, we have here a coefficient of correlation of about .08. Even though the result is statistically significant, it is very doubtful that the conclusion follows. This is evidently a case of confusing statistical significance with practical or scientific significance. If the coefficient is squared, the result yields an estimate of the percentage of the common factor variance shared by the two variables. Squaring it, we get .0064, or about 0.6 percent. Thus, to be generous, it can be said that the variables of this study share about 1 percent of their variance in common! (Incidentally, the assumption of normality is not necessary for computing r, as the authors imply [see M. D. Nefzger and J. Drasgow, *Am. Psychologist* **12**, 623 (1957)]).

FRED N. KERLINGER
School of Education, New York University, New York

In our earlier publication we found and reported a small but statistically significant correlation between score achieved in the Army Classification Battery and serum uric acid concentration in the population studied. Kerlinger apparently agrees with these findings but questions our conclusion, which is merely a restatement of these findings, that the correlation coefficient obtained is positive, small, and significantly different from zero. There is no confusion in our report between "statistical" and "practical" significance, since we have used the term *significant* only in its statistical sense. The correlation was originally examined for what appeared to us to be adequate reasons, stated in our earlier communication, and the value of r, though small, was considered worthy of publication, since it answered a question raised by Haldane [J. B. S. Haldane, *Nature* **176**, 169 (1955)].

The interpretation of the answer is left to the reader. The improvement of the estimation of one variable from the knowledge of its correlation with the other is small by any test, including the statistic r^2 employed by Kerlinger, and it was never our intention to suggest replacement of intelligence testing by serum urate analyses. Although not helpful in the prediction of one variable from knowledge of the other, the correlation might provoke inquiry into a possible biological basis. Incidentally, it was neither stated nor implied that the assumption of normality is necessary for computing r. The assumption is necessary, however, as we have clearly stated, for the test of significance which we employed.

DEWITT STETTEN, JR.
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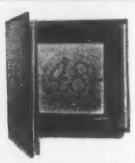

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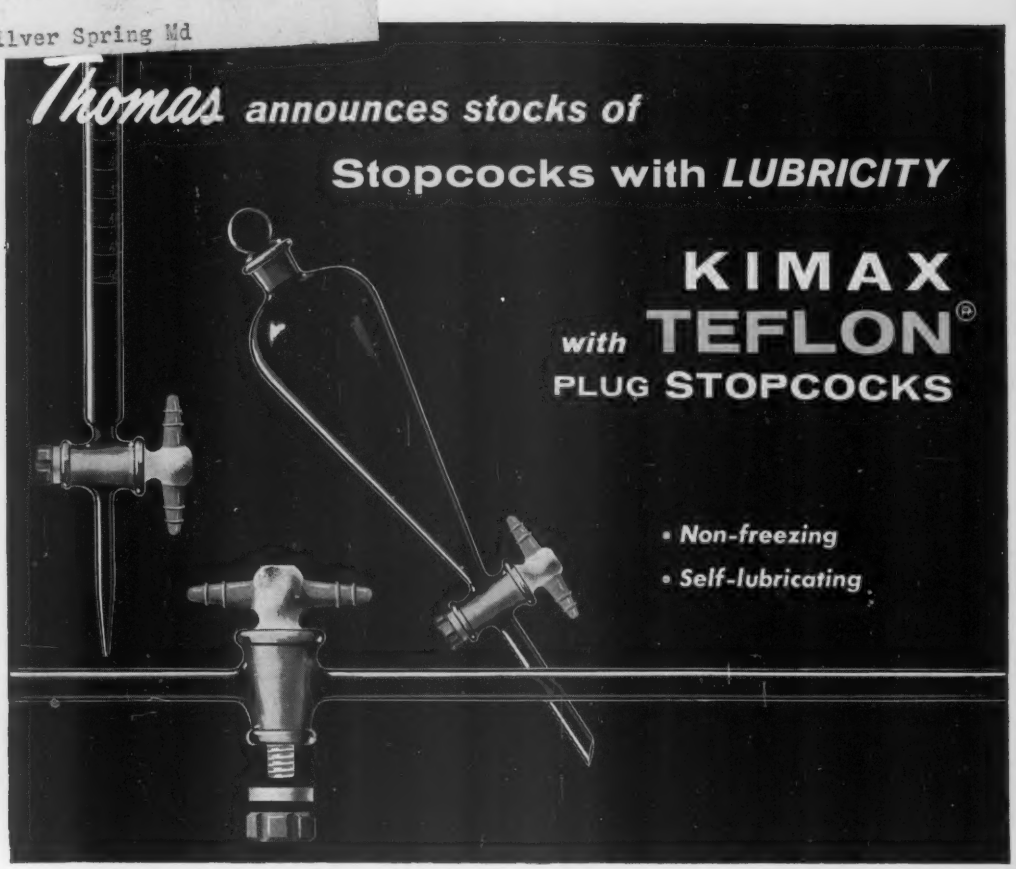

The new Kimble Stopcock† with Teflon* plug combines the well-known advantages of Teflon with some important new features of construction.

Teflon plugs are self-lubricating, non-contaminating and non-freezing even after extended contact with strong caustic solutions. The specially designed washer and nut of the Kimble Stopcock are also of Teflon to facilitate manipulation and prevent binding and leakage.

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*DuPont registered trademark for fluorocarbon resins

†Lab-Crest style Stopcocks with Teflon plugs manufactured by Kimble under Fischer & Porter Patent No. 2,876,985

The following and twenty-six additional items of Kimax borosilicate glassware with Teflon plug stopcocks are illustrated and described in new Kimble bulletin SP-51, copy of which is sent upon request.

2442-X. Burettes, Kimax borosilicate glass, with Size 2 straight bore stopcock with Teflon plug.

Capacity, ml	10	25	50
Graduation interval, ml	1/20	1/10	1/10
Each	8.10	8.10	8.20
Per case containing 4	29.16	29.16	29.52

5630-W2. Funnels, Separatory, Kimax borosilicate glass, with stopcock with Teflon plug.

Capacity, ml	125	250	500	1000
Stopcock size No.	2	2	4	4
Each	8.25	9.80	11.25	15.20
Case contains	4	4	4	2
Per case	29.70	35.28	40.50	27.36

9287-A5. Stopcocks, Kimax borosilicate glass, straight bore, with Teflon plug.

Bore, mm	2	3	4	6
Each	5.40	6.10	8.00	9.60
Per case containing 6	29.16	32.94	43.20	51.84

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